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Supplementary Notes on the Erysiphaceae

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(WITH PLATES 9–11)

(Continued from page 109)

ERYSIPHE POLYGONI DC. (Monograph, p. 174)

Syn. add: *E. Fricki* Neger, Bericht. Deutsch Bot. Gesellsch. **17**: (Generalversamm.-Heft) 241. 1899.

E. pisi DC. var. *desmodii* P. Henn. Engler's Bot. Jahrb. **29**: 148. 1900.

Conidial form: *Oidium monosporum* Passerini, Nuov. Giorn. Bot. Ital. **13**: 282. 1881.

Exsicc. add: * Rehm, Ascomycet. 1350 (sub *Microsphaera Caraganae* P. Magn.); * Krypt. Exsicc. (Mus. Pal. Vind.) 130, 131 (a & c only), 132.

Distrib. add: Europe: Faröe Islands (63), Bosnia (3), Bulgaria (10).

Asia: Siberia, Yeniseisk ("flum. Yenisei inter 58° et 71°") (A. Kitmanoff), Poseka, Wostotchnoje, & Nitchka (Sacc. in Malpighia, **10**: 269. 1896); Palestine (43).

South America: Argentine, "in alta Cordillera, 39° lat. merid. 900 m. supra mare (Neger).

Hosts, add: *Aconitum variegatum* (40), *Actinostemma racemosum*, *Anemone nemorosa* (40), *Aster* sp. (8), *Ballota nigra* (80), *Brassica oleracea* (13*), *Cytisus capitatus* (40), *C. purpureus* (40), *Delphinium hybridum* (cult.), *D. Maackianum* (cult.), *Desmodium podocarpum* var. *Japonicum*, *Dipsacus silvestris* (18), *Echinops* sp.

[Issued 24 April]

(29), *Geranium pratense* (18), *G. Robertianum* (6), *Geum Chiloense*, *Heuchera Americana* (84), *Hieracium umbellatum* (38), *Hypericum tetrapterum* (40), *Isopyrum thalictroides* (40), *Lathyrus Clymenum* (12), *L. montanus*, *L. niger* (40), *L. ochroleucus* (15), *L. palustris* (84), *L. venosus*, *L. vernus* (40), *Leonurus Cardiaca* (80), *Lupinus angustifolius*, *Lycopersicum esculentum* (13*), *Melampyrum silvaticum* (40), *Mentha arvensis* (80), *Myosotis* sp. (80), *Onobrychis Crista-galli* (43), *Papaver Rhoeas*, *Phascolus vulgaris* (18), *Physalis* (29), *Pisum arvense* (18) (49), *Pleurospermum Uralense*, *Ranunculus nemorosus* (33), *R. recurvatus* (8) (84), *Rhabdosciadium Aucheri* (59), *Robinia Pseudacacia*, *Scabiosa stellata*, *S. succisa*, *Sedum Telephium* var. *purpureum* (cult.), *Sisymbrium officinale*, *Sium latifolium* (76), *Sonchus oleraceus* (80), *Thesium alpinum* (40), *Torilis Anthriscus* (40), *Trifolium agrarium*, *T. spadiceum* (40), *Urtica urens*, *Valeriana officinalis* (6), *Valerianella* sp. (80), *V. olitoria* (40), *Vicia tenuifolia* (40), *V. venosa* var. *capitata*.

I have received from Dr. Neger a specimen (now in the Kew Herbarium) of "*Erysiphe Fricki*," labeled "in foliis *Gei Chilensis* Balb. in alta Cordillera 39° lat. merid. 900 m. supra mare." I am quite unable to separate the fungus in any way from *E. polygoni*. The perithecia measure from 90–135 μ in diameter, and contain four to twelve 3–5-spored asci. The asci measure 65–70 × 34–40 μ (*pl. 1, f. 12*). Neger (**52**) gives the size of the asci as "55–65 × 28–35 μ," and states that *E. Fricki* differs from *E. Martii* (= *E. polygoni*) "durch beträchtlich grössere Schläuche (bei *E. Martii* nur 40–50 μ)." I have already pointed out, however (monograph, 178), that in *E. polygoni* the asci vary in size from 46–72 (very rarely reaching to 80 μ) × 30–45 μ. I have seen specimens of *E. polygoni* occurring on *Geum urbanum* in New Zealand.

Hennings (**31**) has described an *Erysiphe* from Japan as follows: "*E. pisi* DC. var. *desmodii*: amphigena, mycelio arachnoideo, tenui, effuso, albido; peritheciis gregariis vel sparsis, atris, globulosis, 80–100 μ, appendicibus hyalinis usque ad 100 μ longis 5–8 μ crassis; 3–4 ascis piriformibus, stipitatis, vertice rotundatis, 50–60 × 30–35 μ; 5–6 sporis ellipsoideis, 1–2-gutulatis, aurantio-oleosis, 17–19 × 14–12 μ. Prov. Musashi: Mt. Takao auf lebenden Blättern von *Desmodium polycarpum* DC. var. *latifolium* Max. (Kusano, no. 132, 18 October 1899)." Hennings remarks of

his plant: "Durch die askenärmeren Perithecien u.s.w. etwas verscheiden von der typischen Art." The character here specially mentioned—and indeed all those given in the diagnosis—are not important enough to separate the present plant even as a variety from *E. polygoni*, and are certainly not confined to the Japanese form, but occur on various hosts throughout Europe and North America. I have received, moreover, from Professor Kingo Miyabe a specimen labeled "*Ersyiphe polygoni* DC. (= *E. pisi* DC. var. *desmodii* P. Henn.). On *Amphicarpaea Edgeworthii* var. *Japonica* (not *Desmodium podocarpum*). Mt. Takao, Prov. Musashi, Oct. 8, 1899, (S. Kusano)." It would appear, therefore, that Hennings has founded his variety on the *Erysiphe* on *Amphicarpaea* This specimen sent by Professor Miyabe also cannot be separated in any way from *E. polygoni*. Professor Shotaro Hori has, however, sent me examples of *E. polygoni* on a host-plant which is certainly *Desmodium*, viz., *D. podocarpum* DC. var. *Japonicum* Maxim (Hakone, Prov. Sagami, Japan, coll. N. Nambu, Oct. 30, 1900). The occurrence of the present species on *Desmodium* is interesting, as hitherto the only mildew known on *Desmodium* (*D. Canadense*, *D. canescens*, *D. cuspidatum*, *D. paniculatum* and *D. sessilifolium*) was *Microsphaera diffusa* Cooke & Peck, which occurs not uncommonly in the United States, but which has not yet been recorded from elsewhere.

Magnus (Bericht. des naturwiss.-med. Ver. Innsbruck, **24**: 6. 1898), has recorded the occurrence of "*Sphaerotheca Castagnei* Lév." on leaves of *Caltha palustris*, from "Schruns in Vorarlberg (J. Bornmüller)." Through the kindness of Professor Magnus I have been able to see the original material on which the above record was based, and have found that the fungus in question is a small—or perhaps starved—form of *E. polygoni*, a species very common on many plants belonging to the Ranunculaceae (*Caltha*, *Clematis*, *Ranunculus*, *Aquilegia*, etc., etc.). This small form of *E. polygoni* is very likely to be mistaken for *S.* "*Castagnei*," and it may be well to point out here the distinguishing characters. In the first place, the appendages of this form of *E. polygoni* have the peculiar *facies* of those of the examples of this species occurring on *Clematis*, *Aquilegia*, *Ranunculus*, etc., and are fewer, longer, slightly wider (especially towards the base) and more distinct, and

often more angularly bent, than the appendages of *S.* "*Castagnei.*" On opening the perithecia, 2 to 4, or rarely 5, asci are found. In Professor Magnus's examples 2 to 3 was the usual number. Very rarely, apparently only a single ascus occurs, but as a rule a second ascus—often empty or more or less aborted—is to be found. In the rare cases in which only a single ascus is observable, this form of *E. polygoni* is easily separable from *S.* "*Castagnei,*" not only by the nature of its appendages, but also by the more or less ovate (not subglobose) ascus, containing (in this form) only 2–3 spores, and not 8 as in *Sphaerotheca.* Moreover, in all such cases, the examination of several perithecia invariably shows the existence in most of several (2 to 5) asci, and so leads us to conclude that the perithecia containing only a single ascus are ill-developed examples. Quite similar specimens of this small form of *E. polygoni* occur on species of *Geranium*, and have been commonly confused with *S. humuli.*

Brannon (8) has reported, in the case of examples of *Sphaerotheca* "*Castagnei* Lév." on a species of *Erigeron*, the finding of two or three perithecia, each containing two asci, and observes: "In these unusual forms one ascus was much larger than its companion, but not as large as the ascus existing alone in a perithecium. A few of these unusual forms might lead to the questioning of what has, heretofore, been considered a strong generic difference between *Sphaerotheca* and *Erysiphe.*" This occasional occurrence of more than one ascus has also been noted by other observers in species of *Sphaerotheca;* in two instances I have found perithecia of *S. mors-uvae* (Schwein.) Berk. & Curt. containing three asci (see monograph, 73). We see, therefore, that in rare instances *Sphaerotheca* may approach *Erysiphe* in possessing more than one ascus; on the other hand perithecia of the small form of *Erysiphe polygoni* on *Caltha palustris*, mentioned above, may very rarely contain only a single ascus. It is clear, therefore, that *Erysiphe* on one side shows an affinity with *Sphaerotheca;* on the other, through *E. tortilis* it claims relationship with *Microsphaera* through *M. astragali* and *M. Bäumleri.*

Brannon (8) has reported the occurrence of *E. polygoni* on a species of *Aster* and considers that this host had probably received the mildew from neighboring plants of *Ranunculus recurvatus* which

were attacked by this species. Species of *Aster* are the common host-plants of *Erysiphe cichoracearum*. If the fungus has been correctly determined, the present instance is of great interest as showing that occasionally a species of mildew is able to pass directly on to the usual host-plants of another species (see p. 14).

In Journ. Myc. **5**: 83. 1899, Kelsey has recorded "*E. communis*" on *Vicia Americana* var. *linearis* (from Helena, Montana, U. S. A.). Specimens communicated to me by the author show that the fungus here recorded is *Microsphaera alni* var. *ludens*. Spegazzini (**79**) has recorded "*E. umbelliferarum*" on *Bowlesia tenera*, from the Argentine, but the fungus, from specimens communicated, proves to belong to *E. cichoracearum*. The *Erysiphe* recorded by Bubak (**9**) as "*E. communis*" on *Plantago major* is *E. cichoracearum*; specimens sent by the author are in the Kew herbarium. The fungus recorded by Saccardo in Rev. Myc. **11**: 41. 1881, as "*E. communis*" on "*Tragopogon* sp.," proves, according to a specimen sent, to be *E. cichoracearum*. The host-plant is not *Tragopogon*; Professor Saccardo, when sending the specimen, wrote on it "fol. *epilobii*," but the fragments sent were too small to admit of certain identification. Professor Saccardo also sent a specimen of the fungus recorded (Bull. Soc. Roy. Bot. Belg. **28**: 86. 1889, as "*E. Martii*" on *Pedicularis resupinata* from Siberia, and this proves to be *Sphaerotheca humuli* var. *fuliginea*. Tolf, in Bot. Notiser, 1891: 219, has recorded "*E. Martii*" on *Astragalus glycyphyllus* and *Vicia cassubica* from Sweden. According to specimens (now in the Kew herbarium) sent by the author, the fungus on the first-named host is *Microsphaera astragali*, and on the second, *M. Bäumleri*. The record by Freeman (**20**), of the occurrence of "*E. communis*" on *Eupatorium ageratoides* belongs to *E. galeopsidis* (see p. 194). Professor Oudemanns writes to me that his record (Rév. Champ. des Pays-Bas. **2**: 97. 1897), of "*E. communis*" on *Geranium molle* was based on the occurrence of merely an *Oidium* on this host, and that the record (*l. c.*) of the occurrence of the same species on *Verbascum Thapsus* was "borrowed from other writers." The fungus recorded by Rabenhorst (**59**) as "*E. Martii*" on *Alhagi maurorum*, *Vicia tenuifolia*, and *Rhabdosciadium Aucheri*, in Kurdistan most probably belongs to *E. taurica*. I have seen several examples of the latter

species on the first two hosts, and there are specimens in the Kew Herbarium labelled "*E. communis leguminosarum.* Ad. *Vicia tenuifolia.* Professor C. Haussknecht, Iter orientale, 1868, Luristan," which belong to *E. taurica.* The fungus recorded by Feltgen (**18**) as "*E. Martii*" or *Lathyrus niger* proves, from specimens sent, to belong to the genus *Microsphaera* and is probably *M. Bäumleri* P. Magn. That, recorded by the same author (*l. c.*), as "*E. pisi*" on *Galium Aparine*, proved, like all records based on the fungus on species of *Galium*, to belong to *E. cichoraceārum.* The host-plant given as *Colutea arborescens* by Sydow, in his Mycotheca Marchica, no. 980, was, as Magnus (**47***) has recently pointed out, wrongly determined and is really *Caragana arborescens. Colutea arborescens* must therefore be removed from the list of the host-plants of *E. polygoni.*

In 1870 de Bary (Beitr. Morph. Phys. Pilze, **1**: 50) raised the "*Erysiphe Martii* forma E." of Léveillé, occurring on various umbelliferous plants (see Lév. Ann. sci. nat. III. **15**: 166. 1851) to specific rank under the name *E. umbelliferārum*, and gave as host-plants *Angelica silvestris, Chaerophyllum hirsutum, Anthriscus silvestris, Pastinaca sativa, Falcaria Rivini* and *Heracleum Sphondylium.* De Bary stated that his species scarcely differed in perithecial characters from "*E. communis*," and remarked "Dagegen ist sie ausgezeichnet durch die Form der Conidien, welche genau walzenförmig, an beiden Enden flach, und mindestens (doch nicht immer) sehr langgestrecht sind. Bei den vorher genannten Arten allen haben die Conidien die (im Profil elliptische) Gestalt einer schmalen an den Enden abgerundeten Tonne." In my monograph (p. 184) I remarked that this character could hardly be considered sufficient to separate "*E. umbelliferārum*" as a species, and also doubted whether it were a constant and distinctive feature of the *Erysiphe* on Umbelliferae. I have since studied in a living state some conidial forms of *E. polygoni*, and have found that the shape of the conidium is extremely variable. On *Sisymbrium Alliaria* (Cruciferae) (*pl. 9, f. 7*) the conidia are for the most part distinctly cylindrical in shape, and intermixed with them one finds quite commonly elliptical conidia. The size of the conidium varies greatly; the cylindrical ones are usually about 38 μ long (and about 15 μ wide), but here and there a

conidium occurs which measures over 50 μ long; the elliptical conidia measure 30–33 × 17–19 μ. On *Heracleum Sphondylium* (Umbelliferae) (*pl. 9, f. 2*) elliptical conidia are of quite common occurrence; considerable variation in size is found also here. On *Anthriscus sylvestris* (Umbelliferae) (*pl. 9, f. 1*) most of the conidia are cylindrical, but occasionally elliptical ones occur. Also, in examples on *Delphinium hybridum*, *D. elatum*, and *D. Maackianum* (Ranunculaceae) (*pl. 9, f. 9*) the shape of the conidia varies from elliptical to cylindrical. The reduction of "*E. umbelliferarum*" to *E. polygoni* appears therefore fully warranted.

It may be here pointed out that, as *f.* 1, 2, and 8 on *pl. 9* show, the conidiophores of *E. polygoni* bear only a single conidium at the apex, unlike the *Oidium* form of many mildews, where the conidia are concatenate in long chains (see monograph *f. 127* for that of *E. galeopsidis*, and *f. 140* for that of *E. cichoracearum*; see also *f. 115*, *117*, and *156*). It would be interesting to ascertain if this feature is characteristic of *E. polygoni*, as if so it might be of use in distinguishing the species in its conidial condition.

In connection with the fact mentioned above of the conidiophores of *E. polygoni* bearing only a single spore, we may note that Passerini has published the following description of a fungus (Nuov. Giorn. Bot. Ital. **13**: 282. 1881): "*Oidium monosporum* Passer. hb. Epiphyllum, maculas discoideas pulveraceo-cinereas demum fuscas efformans. Hyphae longae, subclavatae, articulatae, in sporam unicam oblongo-ellipticam desinentes. An *Ovulariae* Sacc. Michel. **6**: 17, analogum?—Sulle foglie della *Robinia hispida* L. nel R. Orto Botanico, Luglio." Professor C. Avetta has kindly sent me the type-specimens of "*O. monosporum*" from Passerini's herbarium at Parma University, and examination of this has convinced me that the fungus described is merely the conidial stage of *E. polygoni*. The subcylindrical conidia measure from 28–40 μ long × 13–16 μ wide. *E. polygoni* is known to occur on other species of *Robinia* (*R. Pseudacacia* and *R. viscosa*).

In germinating some conidia of *E. polygoni* on *Delphinium Maackianum* in a hanging drop of water, several cases were observed of the formation of lobed "appressoria" at the places

where the tips of the germ-tubes had come into contact with the cover-glass (see *pl. 9, f. 9*). No formation of haustoria proceeding from these was observed. This phenomenon was first noticed by Büsgen (**11**), who remarks of the germinal hyphae proceeding from conidia of *E. polygoni* sown in the same way: "bei Berührung mit dem Objectträger erzeugten sie lappige Appressorien, mit deren Bildung ihr Wachsthum abgeschlossen war. Ein Austreiben der Appressorien fand nicht statt, obwohl der Inhalt der Gonidien noch nicht erschöpft schien. Es darf daraus geschlossen werden, dass auch bei den Erysipheen zur Entwickelung des Infectionsfadens ein Ernährungsreiz nothwendigist, der in der Natur nur von der Wirthspflanze ausgehen kann."

In the Journal of the Royal Horticultural Society (London) for 1900 (**35**) it is reported that the prevalence in autumn, in some parts of Britain, of the "pea-mildew" (*E. polygoni*), is causing the cultivation of late varieties of peas to be abandoned. A similar state of affairs has already been recorded in the western United States by Bessey (Seventh Biennial Report Iowa Agric. Coll., 1877). Dusting the infected plants over with flowers of sulphur (mixed with air-slacked lime), or spraying with a solution made by dissolving 3 oz. of carbonate of copper in 2 quarts of aqua ammonia diluted to 22 gallons, is stated to be the best means of combating the disease. (See Galloway, on the "Powdery Mildew of the Bean," Journ. Myc. **5**: 214. 1889.) Lodeman (**40***, p. 325) writes of the "Pea Mildew": "This disease could undoubtedly be easily checked by means of the copper sprays, but the foliage of these plants is of such a character that liquids do not readily adhere. Soap will assist in overcoming this difficulty if it is added to the liquids. Another line of treatment which might be followed by good results is to apply powder to the vines while they are wet with dew. Fostite should prove of value for this purpose."

In 1891 Comes (**13***) described under the name *Oidium ceratoniae* a mildew which had been observed for several years previously on the carob-tree (*Ceratonia Siliqua*) in southern Italy. This fungus is stated to attack by preference the younger leaflets, which become deformed and fall off, the young shoots, and the immature fruits. When the mildew appears at the time of flower-

ing, fertilization fails—if afterwards, the young fruit does not fall, but usually becomes more or less atrophied or withered on the plant, and is always depreciated in quality. The mildew appears to be more prevalent in wet than in dry years, and is found more in localities in which water remains at the foot of the plant than in those in which the soil being permeable leaves the stock free from water. The disease always begins on trees which have their roots more or less affected and made rotten by stagnant water, and then spreads from these plants radially as from so many centers of infection. The means adopted of dealing with the disease is to bare the roots of the trees most seriously attacked, and to cut off those roots which are more or less rotten; and further to keep the soil soft and permeable at the foot of the trees by burying there faggots or straw. Cutting off the tops of diseased branches is also recommended.

Grimaldi (Come fare fruttificare abbondantemente il carrubio, Palermo, 1895) also reports that the present fungus seriously affects in some seasons the harvest of carob-beans (St. John's bread), and states that the disease is popularly known as "a farinedda."

Although no perithecia were observed on the carob trees affected, Comes referred his "*O. ceratoniae*" to *Phyllactinia corylea*, considering it to be the conidial stage of that species.

In 1899 I received from Professor P. Gennardius, Director of Agriculture, at Nicosia, Cyprus, some diseased pods of *Ceratonia Siliqua*, which on examination were found to be covered with a mildew. The fungus, which was stated to cause great damage to the carob crop in Cyprus in some seasons, is evidently the "*Oidium ceratoniae*" of Comes; it shows, however, all the characters of the conidial stage of *E. polygoni*. The presence of ordinary haustoria on the mycelium proves conclusively that the fungus is not to be referred to *Phyllactinia*. Specimens of "*O. ceratoniae*" have been issued in Briosa e. Cavarra, Fung. par. no. 238, from Sicily, where the fungus is stated to have seriously affected the harvest of carob-beans in 1892. The figures here given represent fairly well the conidial stage of *E. polygoni*. The conidia are described as cylindrical (truncate at the ends) and measuring 26–36 × 12–14 μ, and are stated to differ from those of "*O. erysiphoides*"

in the wall being somewhat rough ("alquanto verrucosa"). The conidia I have seen measure about 30–35 × 12–15 μ, and have a smooth wall, although, as is generally the case with the conidia of the Erysiphaceae, very old conidia, through the wrinkling of the cell-wall, or through incrustation, appear falsely to be rough.

The fungicides, recommended for the "pea mildew" above, should prove efficacious here.

Comes (**13***, p. 246) also records cases of the tomato being seriously affected by the present species, and remarks, "In 1879 the tomato was attacked by it at Palermo. The plants presented grayish spots, which by degrees became black, both on the skin and on the leaves. Microscopic examination showed the presence of an *Erysiphe*, very similar to the preceding [*E. Martii*], but furnished with the characters of *E. communis*. In 1881 it injured the tomatoes in the region of Salerno, and in other localities of northern and central Italy. Moreover, this disease has been known in the region of Palermo for twenty-five to thirty years under the name of *male nero;* it attacks the plant at all seasons, but more readily about the beginning of May. The cultivators think that it is caused by excessive dampness, since the plant, cultivated under dry conditions, is exempt from it. They are convinced that the disease is contagious, and consequently if they observe that the disease appears in a nursery they destroy the affected plants immediately. They hold that sulphuring alone is useless; they are accustomed, instead, to cut back the plants, to leave them dry, and then to sulphur them. When the disease appears before or at the commencement of flowering, they prefer to destroy the affected plants." Tomaro (Le due crittogame che maggiormente danneggiano i pomidori; *cf.* Just's Bot. Jahresber. 1891, **2**: 245, 1893), has also reported the occurrence of "*E. communis*" on the tomato in the neighborhood of Bergamo, and states that the disease was induced by excessive moisture.

Var. SEPULTA (Ell. & Everh.) Salm. (Monograph, p. 191)

Distrib. add: United States of America, California, 7,000′ (A. Purpus) in herb. Jaczewski.

E. CICHORACEARUM DC. (Monograph, p. 193)

Exsicc. add: * Rehm, Ascomycet. 1199; & 1298 sub *E. Martii* Lév. f. *rubiacearum;* Krieg. Fung. saxon. 1218, 1219 1220, 1221 (in herb. Jaczewski).

Distrib. add: Europe: Bosnia, Bulgaria (10), Dalmatia (3).

Asia: Siberia, Yeniseisk, "flum. Yenisei inter 58° et 71°" (A. Kitmanoff), Transcaucasia, Lencoran (59); Turkestan, Taschkent, Tschimkent (79*).

South America: Argentine Republic, "Puente de Inca, Audibus Mendozinis" (C. Spegazzini, May 3, 1901), Flores no. Buenos Aires, Nov. 20, 1888 (C. Spegazzini), Lincoln (79).

Hosts, add: Artemisia serrata (23**), *Aster azureus* (84), *A. lateriflorus* (17), *A. Novae-Angliae* (84), *A. undulatus* (8), *Bidens bipinnata* (79), *Bowlesia tenera, Calendula arvensis* (40), *C. fulgens* (40), *Centaurea Cyanus* (40), *C. pectinata, Cineraria* sp. (75), *Cnicus arvensis, Echinospermum Lappula* (6), *Echium vulgare, Eupatorium ageratoides* (15), *Euphorbia* sp., *Helianthus parviflorus* (84), *Hieracium umbellatum* (76), *Hydrophyllum appendiculatum* (84), *H. macrophyllum* (84), *Inula Britannica, Myosotis* sp. (3), *M. collina* (40), *M. palustris* (40), *M. sparsiflora* (40), *M. stricta* (40), *Parietaria Canadensis* (84), *P. judaica* (40), *Phlomis Herba-venti* (80), *Physalis Alkekengi, Pilea pumila* (84), *Plantago Cornopus* (38), *Salvia glutinosa* (66), *Senecio erucifolius* (34), *S. Fuchsii, S. silvaticus* (40), *S. viscosus* (40), *Solidago latifolia* (84), *Symphytum tauricum, Verbascum Lychnitis, Willughbya scandens* (17), *Zinnia elegans* (84).

A very interesting form (now in the Kew herbarium) has been sent to me by Dr. Spegazzini labelled "*E. andicola* Speg. n. sp. Puente de Inca, Audibus Mendozinis, May 3, 1901. In *Euphorbia* sp." The perithecia measure up to 180 μ in diameter, although most of them are smaller, being of the size, normal for *E. cichoracearum,* the asci measures from 70–85 × 25–30 μ, and the spores up to 28 μ long, although the latter are usually smaller (about 25 μ long). This South American example on *Euphorbia* matches exactly, in the persistent mycelium and the occasionally large size of the perithecium and asci, two North American forms of *E. cichoracearum,*—one on *Lygodesmia juncea,* from Helena, Montana, U. S. A. (Kelsey, September 15, 1890)—the other on *Bige-*

lovia—on *B. viscidiflora* (*B. Douglasii*), Willis, Montana, U. S. A. (F. W. Anderson, Oct. 1888), and on *Bigelovia* sp., Laramie Hills, Wyoming (E. Nelson, September 28, 1897). I have already remarked on the peculiarities of the form on *Bigelovia* (see monograph, p. 203). This South American plant on *Euphorbia*, while much recalling the Old World species *E. taurica* Lév. in habitat, and in the large size of some of the perithecia and asci, yet clearly belongs to *E. cichoracearum*, and exactly matches the large form of this species found on *Arctium* in Europe.

The fungus recorded by Hennings (**30**) as "*E. lamprocarpa*" on *Bigelovia* sp. from "Snow Mount, 7,000 ft., California" is according to a specimen collected by Purpus and labelled "California 7,000 ft." (in herb. Jaczewski) *E. polygoni* var. *sepulta*.

Spegazzini (**79**) has recorded "*E. umbelliferarum*" (= *E. polygoni*) on *Bowlesia tenera* from Flores near Buenos Aires, and in the diagnosis has described the spores as measuring 25–40 μ long × 14–18 μ diam." Professor Spegazzini has sent me a specimen of the plant (labelled "*E. umbelliferarum* var. *platensis*"), which proves to be *E. cichoracearum*. The few spores seen by me measured about 24 × 14 μ. The fungus recorded by Spegazzini (**79**) as "*E. lamprocarpa*" on *Tagetes glandulifera* proves to belong to *E. galeopsidis*.

The records by Bubak (**10**) of *E. cichoracearum* on *Verbascum phlomoides* and *V. Lychnitis* (and probably also that on *V. Blattaria*) from Bulgaria belong to *E. taurica*. Professor Oudemanns writes to me that his record (Rév. Champ. des Pays-Bas, **2**: 94. 1897) of "*E. lamprocarpa*" on *Verbascum thapsiforme* was based merely on the occurrence of an *Oidium* stage on this plant.

I have stated in my monograph (p. 202) that the *Erysiphe* occurring on *Echium* and *Anchusa*, although commonly referred to *E. cichoracearum*, has always proved in my experience to be *E. polygoni*. I have, however, since found in Professor Jaczewski's herbarium, a specimen on *Echium vulgare* ("St. Lubin-de-la-Haye, Eure-et-Loire, France") which is true *E. cichoracearum* (with regularly 2-spored asci, etc.). On *Anchusa*, however, the fungus in all the examples I have seen, belongs to *E. polygoni*—good specimens on this host are to be found in Syd. Myc. March, no. 655.

The fungus recorded by Raciborski (60) as *Oidium tabaci* from Java is probably the conidial stage of *E. cichoracearum*.

Examples of the form of *E. cichoracearum* (on *Galium*) with perithecia containing asci without any trace of spores (see monograph, p. 208) occur in the Paris Museum, labelled "*E. Martii* Lév. sur *Galium*. Souk el Arba [Algeria]. 1er Janvier 1893."

As *E. cichoracearum* frequently proves a serious enemy to cucumber culture—more especially to cucumbers forced in the greenhouse for a winter crop—the following notes on the successful treatment of the disease may be given. Humphrey (31*) states: "The disease may be kept in check in the greenhouse by spraying the plants as often as is necessary with a solution of sulphide of potassium (liver of sulphur) in water, an ounce of the sulphide to four gallons of water. A stronger solution injures the plants and fruits. Spraying with ammoniacal carbonate of copper (3 oz. carbonate of copper dissolved in one quart of ammonia; dilute with water to 25 gallons) has been found even more effective. But Professor Bailey finds more effective than either exposure to sulphur vapor. This is accomplished by closing the house as tightly as possible for half an hour or an hour at a time, while it is filled by the vapor arising from a vessel of sulphur kept a little above the melting point on a small oil stove. The vessel should be porcelain-lined, to protect the iron from the action of the sulphur. Great care must be taken to avoid the ignition of the sulphur." It may be noted that Humphrey found that the conidia of *E. cichoracearum* on cucumber leaves differed considerably in size in examples from different localities.

Stewart (81) records cases of field-grown cucumbers thickly covered with mildew. (See also for "Cucumber mildew," Bailey (2*).)

Oidium chrysanthemi Rabenh. Hedwigia, 1: 19–21. *pl. 3. f. 1.* 1853, is probably the conidial stage of *E. cichoracearum*, and is frequently very troublesome on cultivated chrysanthemums. The fungicides recommended above should be used to check the disease.

E. GALEOPSIDIS DC. (Monograph, p. 204)

Distrib. add: Europe: Bulgaria (10).

Asia: Siberia, Yeniseisk, "flum. Yenisei inter 58° et 71°"

(A. Kitmanoff), Minussinsk (Martianoff), Monastir, Poseka, and Lake Karasin (Saccardo, Malpighia, **10**: 269. 1896).

South America: Argentine Republic, Lincoln (Spegazzini, Sept. 1899).

Hosts, add: Calamintha Acinos (40), *Galeopsis Ladanum* (18) (40), *Lamium amplexicaule*, *Phlomis tuberosa*, *Salvia officinalis* (34), *Scutellaria lateriflora* (84), *S. pilosa* (84), *Tagetes minuta*, *Teucrium Scorodonia*.

Freeman (**20**) has recorded "*E. communis*" on *Eupatorium ageratoides* L. (Hennepin, Oct. 1893. Sheldon 4083). The author kindly sent me part of the original material (now in the Kew herbarium), and I have found that the fungus is the *Erysiphe* with lobed haustoria which I have referred at p. 208 of my monograph with some doubt to *E. galeopsidis*. In the present case, as in the two other examples mentioned in my monograph (*l. c.*), the asci agree with those of *E. galeopsidis* in not containing spores on the living plant. *E. cichoraccarum* with normal bisporous asci occurs on *Eupatorium cannabinum*, *E. perfoliatum*, and *E. purpureum*, and it is certainly very interesting to find on one species of the genus, viz.: *E. ageratoides*, a fungus constantly possessing lobed haustoria and asci without spores—a combination of characters only found in *E. galeopsidis*.

Professor Spegazzini has sent me a specimen (now in the Kew herbarium) of the *Erysiphe* recorded (79) by him as "*E. lamprocarpa* (Wallr.) Lév." on *Tagetes glandulifera* (= *T. minuta*) from Lincoln, Argentine Republic, Sept., 1899. On examining this fungus I found that the asci, although the perithecia in color, etc., appeared ripe, contained no spores, and on searching the mycelium for haustoria it was found that these were, for the most part at any rate, distinctly lobed (see *pl. 9, f. 13*). The fungus consequently must be referred to *E. galeopsidis*. The host-plant in the above case belongs to the Compositae and on this account the record is of special interest. *E. galeopsidis* had been supposed to be confined in its range of host-plants to genera belonging to the Labiatae and to *Chelone* in the Scrophulariaceae until the existence of an *Erysiphe* with lobed haustoria and asci without spores was discovered on *Eupatorium ageratoides* (see paragraph above). We have now an instance of the occurrence in South America of the same fungus on another genus of Compositae.

The fungus recorded by Bubak (**10**) as *E. galeopsidis* on *Marrubium peregrinum* from Bulgaria belongs to *E. taurica*.

Atkinson (Journ. Elisha Mitch. Sci. Soc. **10**: 75. 1894), has recorded *E. galeopsidis* from Alabama, U. S. A., "on *Verbena urticifolia*, October 23, 1891 (coll. B. M. Duggar)." Specimens (now in the Kew herb.) kindly sent to me by the author prove, however, that a wrong identification of the fungus has been made, the species being clearly *E. cichoraceārum* DC., as is shown by the asci containing two or rarely three spores on the living host-plant and by the absence of lobed haustoria on the mycelium.

E. GRAMINIS DC. (Monograph, p. 209)

Ascigerous form.

Exsicc. add: *Linhart Fung. hungar. 80; Krieg, Fung. saxon. 1216, 1217 (in herb. Jaczewski).

Distrib. add: Europe: Faeröe Islands (63).

North America: United States, Indiana (84); East Greenland (Rostrup, Meddel. om Groenland, **18**: 61. 1896.

Australasia: Tasmania (62).

Hosts, add: Bromus mollis, Catabrosa aquatica (40), *Holcus lanatus* (13), *Lolium perenne* (38), *Milium effusum* (76), *Poa alpina* (40).

Conidial form.

Syn. add: Oidium tritici M. A. Libert, Pl. Crypt. Ard. fasc. IV, no. 385 (cum diag.) 1837; Sacc. Syll. Fung. **4**: 46. 1886.

Torula tritici (Lib.) Corda, Ic. Fung. **5**: 51. *pl. 2. f. 15.* 1842.

Torula bulbigera Bonorden, Bot. Zeitung, **19**: 195, *pl. 8. f. 8.* 1861.

Oidium bulbigerum (Bon.) Sacc. & Vogl.; Sacc. Syll. Fung. **4**: 47. 1886.

Torula rubella Bonorden, Bot. Zeitung **19**: 195. 1861.

Oidium rubellum (Bon.) Sacc. & Vogl.; Sacc. Syll. Fung. **4**: 46. 1886.

Exsicc. add: Lib. Pl. Crypt. Ard. fasc. IV, no. 385; Fckl. Fung. Rhen. 72; Jack, Leiner u. Stizenb. Krypt. Bad. 819; Rab. Fung. Eur. 477; Klotzsch, Herb. myc. ed. nov. 81; de Thüm. fung. austr. 541.

(*T. rubella*) Rab. Fung. Eur. 281.

Libert gives the following diagnosis of *Oidium tritici*: "Epiphyllum, caespitibus oblongis confluentibus fulvis; floccis simplicibus erectis in articulos pellucidos ovales secedentibus. Ad folia viva *Trictici repentis*, Aestate." Examination of the specimen of *O. tritici* in Lib. Pl. Crypt. Ard. fasc. IV, no. 385 shows that the fungus is identical with *Oidium monilioides* Link., the conidial stage of *E. graminis*. The bulbiform swelling at the base of the conidiophore seems a constant feature in the conidial stage of *E. graminis* (see monograph, *pl. 9. f. 156*; and also Garovaglio & Cattaneo, Archiv. Lab. Bot. Critt. Univ. Pavia, **2**: *pl. 2.* 1879), and was observed in all the specimens in the exsiccati of "*O. trictici*" quoted above.

Bonorden founded his "*Torula bulbigera*" on Rabenh. Fung. Europ. Cent. II. no. 275, and published the following diagnosis: "Sporis ovatis s. oblongo-ovatis 4–6 concatenatis hyalinis albis, hyphis (pedicellis) triseptatis, basi bulbosis; mycelio ramoso, septato et repente. Hab. in foliis graminum in Guestphalia." From the description and figures given there can be no doubt that "*Torula bulbigera*" is nothing more than *Oidium monilioides*. The inflated base of the conidiophore, relied upon by Bonorden as the chief specific character, is, as has been pointed out above, a constant feature in the conidial form of *E. graminis*. I have not seen Rabenb. Fung. Eur. no. 275.

Torula rubella Bonorden was founded on Rabenh. Fung. Eur. Cent. III. no. 281, and the following diagnosis given: "Sporis ovoideis 3–4 concatenatis; pedicellis articulato-septatis, rubicundis subrubiginosis. Hab. in foliis vivis graminum in Guestphalia." This also proves to be the conidial stage of *E. graminis*. In Rab. Fung. Eur. no. 281, the "*Torula*" can be seen passing over into pannose mycelium in which perithecia of *E. graminis* are immersed. The bulbiform swelling at the base of the conidiophore is present in these examples, just as in "*T. bulbigera*" (see above).

Spegazzini (**79**) records "*Oidium monilioides*" on *Bromus unioloides* and *Avena sativa*, in the "Parque de La Plata, winter 1882–95." Nees (Syst. Pilze u. Schwämme, 53. 1817) records a fungus under the same name from Germany on *Dinebra Arabica* (cult.).

The haustoria of *E. graminis* are peculiar in possessing long

finger-like processes. They have been studied in detail by Grant Smith (**77**), and well figured. (See p. 4.)

E. TORTILIS (Wallr.) Fr. (Monograph, p. 213)

Syn. add: *Trichocladia tortilis* (Wallr.) Neger, Flora, **88**: 351. 1901.

Distrib. add: Bulgaria (10).

The record of the occurrence of *E. tortilis* on *Thalictrum aquilegifolium* by Massalongo (**50**) was due to an error of identification, the fungus in specimens sent to me proving to be *E. polygoni* DC. Professor Oudemanns writes to me, with regard to his record (Rév. Champ. des Pays-Bas, **2**: 95. 1897) of *E. tortilis* on *Cornus alba*, that "the leaves of the *Cornus*, examined with more care, prove not to belong to *C. alba*, but to another garden species, unable to be identified."

E. TAURICA Lév. (Monograph, p. 215)

Distrib. add: Bulgaria.

Hosts, add: *Cerinthe* (80), *Dorycnium herbaceum* (80), *Marrubium peregrinum*, *Saussurea* sp., *Verbascum Lychnitis*.

The example on *Marrubium peregrinum* from Bulgaria is recorded by Bubak (**10**) as *E. galeopsidis*, but from a specimen (now in the Kew herbarium) sent by the author the fungus proves to be *E. taurica*. Similarly, the fungus on *Verbascum phlomoides* and *V. Lychnitis*, referred by the same author to *E. cichoracearum* proves, from specimens sent (now in the Kew herbarium) to belong to *E. taurica*. The same is also probably the case with the fungus on *V. Blattaria*, referred also to *E. cichoracearum*, but the specimen sent is too immature to permit of certain identification, although the habit is that of *E. taurica*. The record by Brunaud (Actes Soc. Linn. Bordeaux, **32**: 155. 1878) of the occurrence of *E. taurica* on *Cnicus lanceolatus* from France proves to be erroneous, the fungus proving, from a specimen sent (now in the Kew herbarium), to be *E. cichoracearum*. Dr. Hennings has sent me from Rabenhorst's herbarium a specimen of the fungus recorded (**59**) as *Sphaerotheca Castagnei* Lév. on *Euphorbia* "am Berge Kellal in Sud-Persien, 10,000′ s. m." The species proves to be *E. taurica*. Another specimen sent from Rabenhorst's herbarium

is the fungus which has been recorded (**59**) as *S. Castagnei* on *Hibiscus esculentus*. This bears no perithecia, but from the mycelial characters shown probably belongs to *E. taurica*.

Oidium haplophyllii P. Magnus (**43**) on *Ruta* (*Haplophyllum*) *Buxbaumii*, from Palestine, is probably the conidial condition of *E. taurica*.

Through the kindness of M. P. Hariot I have seen the specimens, in the Paris Museum, of the fungus recorded by Léveillé (Ann. sci. nat. III. **15**: 161. 1851) as "*E. taurica*. On *Aplotaxis*, Himalaya (Jacquemont. Herb. Par.)." The fungus belongs as named, to the present species, and is growing on some species of *Saussurea* (*Aplotaxis*). The specimens are labelled "*Erysiphe compositarum* Lk.—in fol. *Aplotaxis*. Indes orientales, Jacquemont."

Speschnew (**79***) has lately published as new species of *Erysiphe* two plants occurring in Turkestan on *Euphorbia lanata* and *Acanthophyllum glandulosum*. The following descriptions are given: "*E. euphorbiae* (sp. nov.) N. Speschnew. Mycelio epiphyllo, interdum hypophyllo, constricte effuso, confluente, tenui; hyphis repentibus, ramosis, flexilibus, undulatis, septatis, dense intertextis, crassiusculis, hyalinis, 4,$_9$–7,$_4$ μ crass.; hypopodiis biclavatis, alternis, ca 14,$_8$–22,$_5$ μ; peritheciis gregariis, globosis, dein subglobosis, in villo nidulantibus, 150–180 μ diam., atrobrunneis, setulis hyalinis, aseptatis, anucleatis, undulatis, apice pedaliformibus, 7–9 μ crassis, perithecio duplo longioribus; ascis elongato-piriformibus, de medio attritis, apice obtusis, operculatis, 3–6-sporis, 90–98 × 22–24 μ; sporis ellipsoideis, continuis, aseptatis, hyalinis, 20–24 × 11–15 μ; hyphis conidii feris illis mycelii similibus, conidiis elongato-ovoideis, mediocre cuncatis, 20–24 × 12–16 μ, episporio valde crasso, 2–3 μ. Habitat in foliis *Euphorbiae lanatae* Sisb. Primo leg. auct. prope Taschkent, 22, ix, 1898. *E. acanthophylli* (sp. nov.) N. Speschnew. Mycelio hypophyllo; hyphis tenuibus, non constringentibus, ramosis vel simplicibus, septatis, valde undulatis, achrois, granulatis, 1,$_5$–2 μ crassis; hypopodiis nodosis, bifurcatis; peritheciis epiphyllis, solitariis, sparsis, haud immersis, globosis vel subglobosis, ca 160 μ diam., atris; setulis rectis, continuis, nucleatis, apice rotundatis, 2–3 μ crassis; ascis late piriformibus, 8-sporis, 38 × 28 μ; ascosporis subsphaericis, continuis, aseptatis, hyalinis, ca 8 μ diam.; hyphis

conidiiferis illis mycelii similibus, conidiis elongato-ovoideis, ca 38–43 × 16–19 μ, episporio tenuissimo. Habitat in foliis cauleque *Acanthophylli glandulosi* Bg. Taschkent, Bukhara, Tschardjui, 27, ix, 1898."

The original Latin diagnoses given by Speschnew are rendered somewhat obscure by faulty construction. As far as possible I have corrected the mistakes in the diagnoses given above. From the description and figures given by Speschnew I am strongly inclined to think that both "*E. euphorbiae*" and "*E. acanthophylli*" are to be referred to *E. taurica*, notwithstanding the fact that Speschnew gives the number of spores in the ascus as 3–6 in "*E. euphorbiae*" and 8 in *E. acanthophylli*, while in *E. taurica*, in my experience, the asci contain when ripe only two spores. It is to be noted, however, that the young asci of *E. taurica* frequently contain one or two, or more, drops of oily matter, which much resemble immature spores. From the figures given by Speschnew, I am inclined to think that this author had under observation immature asci containing young spores and oily globules. The mistake of describing these oily globules as spores has apparently somewhat frequently occurred. "*Erysiphe lanuginosa*" (= *E. taurica*) on *Daucus maximus*, from Greece, was described by Fuckel (Bot. Zeitung, **29**: 27. 1871), as possessing 8–12-spored asci, but in the examination of authentic specimens I have found the asci constantly bisporous. Two plants from Persia, in all probability the same as those found by Speschnew, have been described by Magnus as "*Erysiphe lanata*" on *Euphorbia lanata* and "*Microsphaera Bornmuelleriana*" on *Acanthophyllum glandulosum*, both of which I have referred at p. 218 of my monograph to *E. taurica*. The asci of "*E. lanata*" were described as containing 3–5 spores and those of "*M. Bornmuelleriana*" 4–6 spores. In specimens of these plants from Magnus' herbarium, however, I have been able to find in the ripe ascus only two spores. It is, however, quite possible that forms of *E. taurica* may occur with occasionally 3 or 4 spores in the ascus, for we must remember that this is the case with several species which are typically bisporous, *e. g.*, *E. cichoracearum* DC., *Uncinula clandestina* (Biv. Bern.) Schroet., *U. polychaeta* (Berk. & Curt.) Ellis, and *Phyllactinia corylea* (Pers.) Karst.

E. AGGREGATA (Peck) Farl. (Monograph, p. 221)

Exsicc. add: Shear, New York Fungi 147 (in herb. Jaczewski).

Distrib. add: Wisconsin (15).

Freeman (**20**) has reported the occurrence, from Minnesota, U. S. A., of the present species on the leaves of *Alnus incana*. The author has since written to me, however, that this record is a mistake, the habitat being, as is invariably the case, the cones of the *Alnus*.

PHYLLACTINIA CORYLEA (Pers.) Karst. (Monograph, p. 224)

Syn. add: *Erysiphe stellata* and vars. *coryli* and *alni* L. Marchand, Bijdr. tot de Natuurk. Wetensch. (Amsterdam), **4**: 272. 1829.

E. fungicola Schulz. Oest. Bot. Zeit. **26**: 58. 1876.

Phyllactinia fungicola (Schulz.) Hazslinszky, M. Tud. Akad. Math. és Természettud. Közlemények, **14**: 181. 1876–77.

? *P. fungicola* (Schulz.) Saccardo, Syll. Fung. **1**: 6. 1882.

P. clavariaeformis Neger, Bot. Centralbl. **80**: 11. 1899; Neger, Ber. Deutsch. Bot. Gesellsch. **17**: 235. 1899.

P. suffulta (Reb.) Sacc. var. *moricola* P. Henn. Engler's Bot. Jahrb. **28**: 271. 1900.

Excicc. add: * Ell. & Everh. Fung. Columb. 108 (b); * Krieg. Fung. saxon. 1226; * Krypt. exsicc. (Mus. Pal. Vind.) 120; * D. Sacc. Myc. Ital. 59, 475; * Fl. exsicc. austro-hungar. 2368; * Linhart, Fung. hungar. 255, 454, 455.

Distrib. add: North America: United States; Minnesota, Florida, New Jersey and Nebraska (17).

South America: "Carren-leofù, Patagonia andina, Jan. 1900 (Spegazzini); Lion Range, nr. Gregory Bay, Patagonia, April 20, 1882 (Spegazzini); Santa Cruz, Patagonia, Jan. 1882 (Spegazzini); Puente de Vacas, Andibus Mendozinis, Argentine, 2,500 m. alt., Mar. 2, 1901 (Spegazzini), Paraguay.

Hosts, add: *Adesmia* sp., *Aesculus Hippocastanum* (18), *Alnus incana* var. *glauca*, *A. viridis*, *Amelanchier Asiatica*, *Anarthrophyllum rigidum*, *Caesalpinia sepiaria*, *Crataegus nigra* (40), *C. parvifolia*, *Desmodium* sp. (8), *Embothrium coccineum*, *Excoecaria* sp., *Fraxinus oxyphylla* (59), *Juglans* sp. (27), *Magnolia Yulan*, *Populus* sp. (27) (28), *Pyrus Malus* (34), *Quercus Kelloggii*, *Ribes Magellanicum*, *Syringa vulgaris*, *Tilia* sp. (27).

Neger (**52**) has described a *Phyllactinia* from South America as a new species with the following diagnosis: *P. clavariaeformis* Neger n. sp. *Ph.* hypophylla mycelio latissimo per totam matricem effuso, peritheciis numerosis, laxe confertis, globoso-depressis, 100–122 μ altis, 200–230 μ latis, verrucosis, atro-opacis, 6–9 appendicibus suffultis; appendicibus 180–350 μ longis (plerumque 200–250 μ), media longitudine interdum subincrassatis; ascis 8–12 in quoque perithecio, ellipticis vel ovatis, apice truncatis, 62–75 μ longis, crasse stipitatis (stipite 12 μ longo, curvato), 2–4 sporis; sporis ellipticis continuis grosse guttulatis.—Species a *Ph. suffulta* Sacc. longe recedens cellulis penicilliformibus (peritheciis insidentibus) valde ramosis, formam *clavariae* cuiusdam ramosae imitantibus. *Ph. Antarctica* Speg. periheciis appendicibusque maioribus distincta." *P. clavariaeformis* is recorded "in foliis viventibus *Ribis* (*glandulosae* R. et. P.?) ad lacum dictum Quillon rei publicae argentinae (regionis andinae)"; also on *Embothrium coccineum* from the same locality, and on *Adesmia* sp. "im Pililthal (Argentien, Quellgebiet des Rio Alominé)."

Neger states that he finds, from an examination of the material in the Berlin Herbarium, that the penicillate cells of the perithecia of *P. corylea* are in their unbranched part relatively short (about 30–40 μ), while in *P. clavariaeformis* this part is considerably longer (60–100 μ). The main difference, however, according to Neger, between *P. corylea* and *P. clavariaeformis* is stated thus: Man beobachtet, dass bei *Ph. guttata* [= *P. corylea*] die Pinselzellen sich unmittelbar am Scheitel in zahlreiche an der Spitze mit einem stark lichtbrechenden Knopfversehene Fäden zertheilen; nur selten ist am Scheitel der Stielzelle eine seichte Zwei oder Dreitheilung zu beobachten. Bei *Ph. clavariaeformis* hingegen ist die Stielzelle in einer gewissen Höhe (ca. 30 bis 70 μ von der Basis entfernt) in 3, seltener 2 Aeste getheilt. Diese Verzweigung ist im entwickelten Zustand mehrfach wiederholb und überaus charakteristisch. Sie erinnert an diejenige gewisser verzweigter *Clavaria*-Arten; die fadenartigen Ausläufer der Verzweigungen unterscheiden sich in nichts von denjenigen der *Ph. guttata*."

In order to ascertain if the characters here given were sufficiently distinctive and sufficiently constant to be of specific value, I have examined the whole of the rich material of *P. corylea*—

numbering several hundred specimens—in the Kew herbarium. The evidence obtained from the examination of these specimens (which come from all parts of the world) forces me to conclude that "*P. clavariaeformis*" is not a distinct species from *P. corylea*, and further that it is impossible to give specific value to such characters as the shape, size, etc., of the penicillate cells. The shape of the penicillate cells, in "*P. clavariaeformis*" is shown at *pl. 10, f. 1–6*, drawn from specimens (now in the Kew herbarium), on *Embothrium coccineum*, sent by Dr. Neger. Most of the cells are branched in a more or less "clavarioid" manner as described by Neger, but intermixed with these there occur not uncommonly apparently fully grown cells which are scarcely branched at all. (See *figs.*) In two specimens of the fungus called *P. Antarctica* by Spegazzini on *Ribes Magellanicum*—one from "Carren-leofú, Patagonia andina, January, 1900 (Spegazzini),"—the other (leg. P. Dusén, May, 1896) sent by Dr. Neger from Dr. Rehm's Herbarium,—the penicillate cells are formed as shown at *pl. 10, f. 10–12*. The majority of the cells show a "clavarioid" branching like that found in "*P. clavariaeformis*," and mixed among these simple or only slightly branched cells occasionally occur. In a third specimen, also on *R. Magellanicum* of "*P. Antarctica*" from "Lion Range, nr. Gregory Bay, Patagonia, April 20, 1882 (Spegazzini)"—the type locality—the penicillate cells are quite as much branched (see *pl. 10, f. 7–9*) as in "*P. clavariaeformis*," so that were the plant possessing penicillate cells with "clavarioid" branching to be kept distinct from *P. corylea*, it would have to bear the older name of *P. Antarctica* Speg. Dr. Neger writes to me that he is now of the opinion that his "*P. clavariaeformis*" is identical with "*P. Antarctica.*" In a specimen labelled *P. corylea* from "Puente de Vapas, Andibus Mendozinis, 2,500 m. alt., March 2, 1901, in foliis vivis *Adesmiae* sp.," sent by Professor Spegazzini. I have found after examining some thirty or forty perithecia only unbranched penicillate cells (see *pl. 10, f. 13*). This is interesting as Neger has referred (**52**) a *Phyllactinia* on *Adesmia* sp. to "*P. clavariaeformis.*" We must conclude, therefore, that on the same genus of host-plants, if not on the same species, the penicillate cells of *Phyllactinia* are sometimes simple and sometimes branched. An example on *Excoecaria*

from "Paraguay, May 1883, nr. 3815" sent by Professor Spegazzini as "*P. suffulta* (Reb.) Sacc." [= *P. corylea*] is of interest from the fact that on the same perithecium we find, in about equal number, simple and branched penicillate cells (*pl. 10, f. 14–15*). [This is the plant recorded by Spegazzini, in "Fungi Guaranatici" (Anal. Soc. Cientif. Argentina, **20**: 66. 1886) as growing on *Colliguaya Brasiliensis*. This last name must therefore be expunged from the list of host-plants of *P. corylea*, as Professor Spegazzini has now written "*Excoccaria*" on the label of the specimen.]

It is, however, when we observe the variation which occurs in the shape of the penicillate cells in examples of *P. corylea* from different parts of the world that we obtain the most convincing evidence as to the worthlessness of the characters given as distinguishing "*P. clavariaeformis*."

Taking first examples on various hosts in the United States, we find that a perfect series of intermediates exists between forms having branched or unbranched penicillate cells. In the specimens in Rav. Fung. amer. exsicc. no. 624, on *Alnus serrulata*, we find "clavarioid" branching in comparatively short cells (*pl. 10, f. 16–18*), on *Corylus Americana* similarly shaped cells occur, on *Alnus serrulata* (from South Carolina) much branched cells (*pl. 10, f. 16–18*), quite similar to those of "*P. clavariaeformis*," are found intermixed with unbranched ones; the same may be observed in the specimens in Ellis' North American Fungi, no. 1327, (*a*), on *Corylus Americana* (from Pennsylvania). Branched penicillate cells, intermixed with unbranched ones, also occur in specimens on *Carpinus Americana* (from Illinois) (see *pl. 10, f. 19*), on *Vaccinium stamineum* (from West Virginia) and on *Cornus Nuttallii* and *Quercus* (*pl. 11, f. 1*). The most remarkable North American form of *P. corylea*, however, occurs on *Catalpa syringaefolia*, from Aiken, South Carolina (Roumeg. Fung. select. exsicc. no. 4756). Here the branched stem-cell is, comparatively, extremely broad, measuring up to 35 μ across (*pl. 11, f. 2–5*). If, following Neger (see above) we took such a character as the length of the stem-cell of the penicillate cells as of specific value, then we should be compelled to make another "species" of a plant possessing such remarkably shaped stem-cells as these found on the *Phyllactinia* on *Catalpa*.

Proceeding to European material we may notice first that in some specimens of *P. corylea* on *Corylus Avellana* a slight but distinct branching is found in some of the penicillate cells. I have seen this in specimens from Surrey, England (*pl. 11, f. 7*), and in the specimens in Briosi e Cavarra, Fung. par. no. 170, from Italy. Ina specimen on *Corylus Colurna* from Copenhagen most of the stem-cells are branched at the apex in the manner shown at *pl. 11, f. 8*. The same occasional branching is found in some specimens on *Alnus, c. g.*, in Fckl. Fung. Rhen. no. 704 (*pl. 11, f. 11*). The degree of branching gradually increases until we find forms like that which occasionally occurs on *Betula alba* (see *pl. 11, f. 9, 10*) from Germany in which the branching is as "clavarioid" as that found in the South American "*P. clavariaeformis.*" In certain specimens occurring on *Alnus glutinosa* (see *pl. 11, f. 12, 13*) drawn from a French example we find an elongated stem-cell, up to 80 μ long, as is usually the case in *P. clavariaeformis* (*cf. pl. 9, f. 1–5*). In a specimen on *Cornus Mas* from Italy (in Sacc. Myc. Ven. no. 625), several cells branched in the manner shown at *pl. 11, f. 14*, were found on the same perithecium amongst quite simple ones.

In most Japanese examples of *P. corylea* the penicillate cells were found to be unbranched, but here, as apparently everywhere in the geographical range of the species, occasional forms occur with a "clavarioid" branching. In specimens on *Magnolia conspicua* (*M. Yulan*), we find branched and unbranched cells in about equal number on the same perithecium (see *pl. 11, f. 17–19*). In the large form of *P. corylea* on *Paulownia imperialis* (see monograph, p. 233) the stem-cell may reach to a height of 110 μ, and be either branched or unbranched. (See *pl. 11, f. 15–16.*) Distinctly branched penicillate cells also occur, intermixed with unbranched ones, on Japanese examples of *P. corylea* or *Alnus incana* var. *glauca* and on *Broussonetia papyrifera.*

We must conclude, I think, from the evidence given above, that *P. clavariaeformis* has no claims to be considered a distinct species, but that it is merely a form of *P. corylea* which appears occasionally—and certainly not confined to any definite host-plants—throughout the geographical range of this species, and that moreover it is a form which merges imperceptibly into typical *P. corylea*

(*cf.* figs. on *pl. 10, 11*). Considering the peculiar shape of the penicillate cells shown by some forms we may perhaps suspect that in such variation there is to be found the origin of an incipient species—in other words that throughout the geographical range of *P. corylea* an incipient species is evolving on these lines from the parent form. The characters of this form, however, are not yet sufficiently sharply marked off, and are altogether too sporadic in appearance to allow us to give the form a place in systematic classification.

As is now well known, the apex of the perithecium of *P. corylea* is provided with a mass of penicillate cells—outgrowths from the external cells of the perithecial wall—which at a certain stage in the ripening of the perithecium and probably under certain external conditions, become mucilaginous and perform a curious function in the life history of the species. At the stage referred to the perithecium bears a large whitish mucilaginous drop on its upper surface. Neger (**54**) mentions that he has observed swimming about in isolated patches over the surface of this drop a foam-like mass, the separate bubbles of which bear a strong resemblance to polygonal thin-walled cells. This is evidently, as Neger observes, the structure represented by Tulasne (Carpologia, **1** : *pl. 1. f. 2, 5, 6*) as a continuous cellular membrane covering over the penicillate cells. In contact with water the cellular appearance of this mass is soon lost, and the whole disappears, leaving nothing behind but a mere trace of a hyaline mucilaginous substance. Neger states that the foam-like mass, together with the mucilaginous drop, is excreted from the perithecium. By a mechanism to be described later, the attachment of the perithecia to the leaf is destroyed, and each perithecium stands free on the points of its reflexed appendages among the hairs, etc., of the leaf, and is liable to fall at the slightest touch to the leaf or to be blown away by a breath of wind. At this stage the wall of the ultimate branches of the penicillate cells breaks down into a mucilaginous substance. When the fungus reaches a new substratum, the reflexed position of the appendages causes the apex of the perithecium, bearing its drop of mucilage, sooner or later to come into contact with the surface of the leaf, etc., on which the perithecium has fallen. The mucilage

adheres to the substratum, and hardens, so that a reattachment of the perithecium, in a reversed position, takes place, and so firm is this attachment that some force is necessary to remove the perithecium with a needle. This curious phenomenon can easily be observed in nature, since on most host-plants perithecia are to be found late in the season attached to the upper surface of the leaves—a position in which they could not, in most cases, have originated, but which is to be explained by their having dropped off from the under surface of higher borne leaves, and become reattached by the mucilaginous cells. This reattachment has been the cause of leading systematists into several curious errors. In the first place there is no doubt that the numerous herbs given as hosts for *P. corylea* are not hosts in the true sense of the word at all, but are merely the plants to which perithecia, blown by the wind or fallen from the leaves of trees above, have become attached in the manner just described. Neger (**53**) records the occurrence of perithecia transferred in this way to plants of *Viola*, *Urtica*, *Onobrychis*, *Lamium*, etc., which were growing under a tree of *Corylus* attacked by *P. corylea*. Saccardo (**66**) records on *Plantago lanceolata* perithecia of *P. corylea* "evidently proceeding from leaves of trees." I have seen perithecia firmly attached to the wood of *Fraxinus* (see monograph, p. 234), and they have been recorded also on grasses and on *Pertusaria* by Bagge (see Fuckel, Symb. Myc. 80). The fungus recorded as "*Erysiphe graminis* DC.?" on the leaves and stems of *Poa nemoralis* and *Festuca sylvatica* by Richon (Cat. Champignons de la Marne, 232, 1889) with the description "Les périthèces sont ornés de 6 ou 8 appendices simples et renflés à la base. Il constitue probablement une variété de *Phyllactinia suffulta* non signalée par les anteurs et différente de l'*Erysiphe graminis* de Saccardo," may now safely be identified as *P. corylea*. "*Erysiphella Carestiana* Sacc." was founded on perithecia attached by means of their penicillate cells to the pileus of *Fomes fomentarius*. There seems also every reason to believe that the "*Erysiphe fungicola*" of Schulzer on *Boletus duriusculus* is nothing more than *P. corylea*. Hazslinszky (**27**, p. 181) gives the following description of the fungus: (I am indebted to Professor A. Mágócsy-Dietz for the translation from the Hungarian): "Perithecien zerstreut und nicht zahlreich, winzig; auf einem aus

radförmig-strahlig sich verbreitenden Mycelfäden sich aufbauenden besonderen Mycelium. Asci länglich mit 1–5 Sporen. Anhängsel ähnlich denen von *Ph. guttata*. Conidien wurden bis jetzt noch nicht beobachtet. Auf verkümmerten Fruchtkörper von *Boletus* bei Vinkovce in Slavonien Königreich Ungarn." From this description we may conclude, I think, that perithecia of *P. corylea*, attached by their penicillate cells to the pileus of the *Boletus*, were under observation. In Schulzer's original diagnosis (Oest. Bot. Zeit. **26**: 58. 1876), the description occurs, "Die Pyrenien [= perithecia] sitzen, jede für sich, auf einem aus strahlenförmigen kürzeren und längeren Hyphen bestehenden Mycelium." The "mycelium" here described by both authors, probably refers as Neger (**53**) has suggested, to the spreading penicillate cells, which frequently form a membranous mycelium-like layer under the perithecium and often extend a little way beyond it.

The loosening of the perithecium from its original point of attachment is, as Neger (**54**) has pointed out, brought about by a special contrivance. The wall of the bulbiform base of the appendages is, according to Neger, thickened in all parts except in the lower quadrant nearest the perithecium (see *pl. 11, f. 20, 21*), copied from Neger. If a living perithecium (the appendages of which will be spreading horizontally more or less in the plane of the leaf on which the fungus is growing) is placed in a dry atmosphere or in a salt solution, the watery contents of the basal bulbous part of the appendage diffuse through the thin-walled part. This causes a folding to take place at this spot (see *f. 20*) and a consequent turning downward of the whole appendage, until at last the perithecium is forced away from its point of attachment and stands loose on the points of the reflexed appendages. In a damp atmosphere, or in contact with water, the bulb swells out again in the folded part, and so causes the appendages to become horizontal again. Neger observes that an appreciable force is exerted by the appendages in turning downwards in the manner described above, and mentions that a rather thick cover-glass, which was placed on four perithecia, was, in an exsiccator, easily raised up by them.

It is worth while noting that some examples of *P. corylea* on *Fraxinus excelsior* possess asci which nearly always contain three

spores. This is the case, *e. g.*, with the specimens in Rabenh. Fung. Eur. 1056 (from Saxony), in which nearly all the asci are trisporous, only rarely being bi- or tetrasporous (see *pl. 9, f. 14, 15*). This fact is interesting for two reasons. In the first place, for the evidence it affords in the question of the specific worth of "*P. Candollei* Lév." (see monograph, p. 230); and, secondly, for the parallel it offers to the variation found in *Uncinula polychaeta*. This species of *Uncinula* in the United States possesses as a rule regularly bisporous asci, only very rarely showing three (or, according to Tracy and Galloway, four) spores in the ascus; in China and Japan, however, the asci are usually trisporous, but sometimes bisporous, or rarely show four or even five spores. In the case of *U. polychaeta* the form which shows an increased number of spores in the ascus is more or less definitely connected with a certain area in the geographical range of the species, while in *P. corylea* this variation occurs quite independent of locality.

P. corylea has been described as being sometimes amphigenous; I believe, however, that this is erroneous, and that its mycelium is always strictly hypophyllous. The description of the species as epiphyllous is probably due to the fact that perithecia attached by their penicillate cells occur very commonly on the upper surface of leaves, and also to the fact that an epiphyllous species of mildew may grow on the same leaf with the *Phyllactinia*. In the Kew herbarium, *e. g.*, there are leaves of a *Quercus*, from the United States, which bear on the under surface the mycelium and perithecia in all stages of development of *P. corylea*, while on the upper surface there are the mycelium and perithecia of *Microsphaera alni*, and among the mycelium perithecia of *P. corylea* attached by their penicellate cells.

Freeman (**20**) has recorded the occurrence of *P. corylea* on *Tilia* sp. from Minnesota, U. S. A., but the author has since written to me that this record must be expunged, the host-plant proving to be probably a species of *Cornus*.

Feltgen (**18**) wrongly refers the name "*Erysiphe stellata* γ *alni* Marchand to *Microsphaera alni*. Marchand (**49**) described his plant as follows: "*E. stellata* N. Hypophylla, filamentis plurimis, tenibus, stellato-expansis. N. β *coryli* N.—*Erysiphe coryli* Hedw. γ *alni* N.—*E. alni* DC." The description given, and the synonymy quoted, show without doubt that *P. corylea* was intended.

Explanation of Plates

(All figures, unless otherwise stated, are magnified 400 times)

PLATE 9

FIG. 1. Conidial stage of *Erysiphe polygoni* DC. on *Anthriscus sylvestris*, from Reigate, England, Sept. 1900; conidiophore bearing a single conidium, and conidia.

FIG. 2. Conidial stage of *E. polygoni* DC. on *Heracleum sphondylium*, from Reigate, England, Oct. 1900, two conidiophores, each bearing a single conidium and conidia.

FIGS. 3–6. *Microsphaera euonymi* (DC.) Sacc. on *Caragana frutescens*, from Russia (in herb. Jaczewski); 3–5, apex of three appendages of the perithecium; 6, ascus and ripe ascospores.

FIG. 7. Conidia of *E. polygoni* DC. on *Sisymbrium Alliaria*, from Kew, England, Oct. 1900.

FIG. 8. Conidial stage of *E. polygoni* DC. on *Delphinium hybridum*, from Kew, England, Sept. 1900; two conidiophores, each bearing a single conidium, and conidia.

FIG. 9. Germinating conidium of *E. polygoni* DC. on *Delphinium hybridum* in a drop of water, showing the formation of an appressorium at the point where the germ-tube came in contact with the cover-glass.

FIG. 10. Apex of an appendage of the perithecium of "*Microsphaera Myoschili* Neger" (= *M. alni* (Wallr.)) on *Myoschilos oblongum*, from the Andes, Argentine Republic (ex herb. Neger.)

FIG. 11. Apex of an appendage of the perithecium of *M. alni* (Wallr.), on *Rhamnus catharticа*, from Brandenburg, Germany (Rehm. Ascomycet. no. 1117).

FIG. 12. Ascus and ripe ascospores of "*E ysiphe Fricki* Neger" (= *E. polygoni* DC.), on *Geum Chiloënse*, from the Argentine Republic (ex. herb. Neger).

FIG. 13. Lobed haustoria of *E. galeopsidis* DC. on *Tagetes minuta*, from Lincoln, Argentine Republic (ex. herb Spegazzini), × 670.

FIGS. 14, 15. Tri- and tetrasporous asci of *Phyllactinia corylea* (Pers.) Karst., on *Fraxinus Ornus*, from Saxony (Rabenh. Fung. eur. no. 1056).

FIGS. 16, 17. Apex of two (partly immature) appendages of *Microsphaera alni* (Wallr.) on *Berberis vulgaris*, from Russia (Jacz. Kom. Tranz. Fung. ross. exsicc. no. 337 b., sub *M. berberidis*).

PLATE 10

Penicillate cells of the perithecium of *Phyllactinia corylea* (Pers.) Karst., from examples from different parts of the world.

FIGS. 1–6. "*P. clavariaeformis* Neger," on *Embothrium coccineum*, from the Argentine Republic (ex herb. Neger); 6, ascus and ripe ascospores of same.

FIGS. 7–9. "*P. Antarctica* Speg.," on *Ribes Magellanicum*, from Lion Range, nr. Gregory Bay, Patagonia (ex herb. Spegazzini).

FIGS. 10–12. *P. Antarctica* Speg.," on *Ribes Magellanicum*, from Patagonia (ex herb. Dr. Rehm).

FIG. 13. On *Adesmia* sp., from the Argentine Republic (ex herb. Spegazzini).

FIGS. 14–15. On *Excoecaria* sp., from Paraguay (ex herb. Spegazzini).

FIGS. 16–18. On *Alnus serrulata*, from South Carolina, U. S. A. (Rav. Fung. amer. exsicc. no. 624, in herb. Kew).

FIG. 19. On *Carpinus Americana*, from Illinois, U. S. A. (Herb. Kew).

PLATE 11

Penicillate cells of the perithecium of *Phyllactinia corylea* (Pers.) Karst., from examples from different parts of the world.

FIG. 1. On *Quercus*, from the United States (Herb. Kew).

FIGS. 2–5. On *Catalpa syringaefolia* from South Carolina, U. S. A. (Roumeg. Fung. select. exsicc. no. 4756, in herb. Kew).

FIG. 6. On *Corylus Americana*, from Illinois, U. S. A. (Herb. Kew).

FIG. 7. On *Corylus Avellana*, from Surrey, England.

FIG. 8. On *Corylus Colurna*, from Copenhagen, (Herb. Kew).

FIGS. 9, 10. On *Betula alba*, from Germany (Herb. Kew).

FIG. 11. On *Alnus* sp. from Germany (Fckl. Fung. Rhen., no. 704, in herb. Kew).

FIGS. 12, 13. On *Alnus glutinosa*, from France (Herb. Kew).

FIG. 14. On *Cornus Mas*, from Italy (Sacc. Myc. Ven. no. 625, in herb. Kew).

FIGS. 15, 16. On *Paulownia imperialis*, from Japan (Herb. Kew).

FIGS. 17, 19. On *Magnolia Yulan*, from Japan (Herb. Kew).

FIGS. 20, 21. Bulbous base of an appendage of *P. corylea*; 20, in a turgescent condition; 21, on loss of turgescence, × 300 (from the drawing given by Neger (**54**, *f.* 14.

FIG 22. Ascospores from an example of *Podosphaera oxyacanthae* (DC.) de Bary, on *Crataegus Oxyacantha*, from Italy. The figures are copied from drawings made by Dr. Spegazzini on the specimen in his herbarium (see p. 84).

(To be concluded.)

Development of the Embryo-sac and Embryo of Castalia odorata and Nymphaea advena*

By Melville Thurston Cook

(With Plates 12 and 13)

The systematic position of the Nymphaeaceae has long been an unsettled question, since the family presents some characters of both monocotyledons and dicotyledons. The purpose of this study was to reach some satisfactory conclusion as a result of observation on the development of the embryo-sac and the embryo. *Castalia odorata* Dryand, and *Nymphaea advena* Soland, were selected and the study has shown that they differ in very few and minor points in their development. Since beginning these investigations, Lyon has published "Observations on Embryogeny of Nelumbo" (9) in which he reaches the conclusion that it is a true monocotyledon in which the single cotyledon bifurcates, thus giving rise to the two fleshy bodies.

The material was killed and fixed in Flemming's osmic-chromo-acetic solution and in chromo-acetic. It was then washed, passed through alcohol, imbedded in paraffine and cut with Minot microtome. The stains used were haematoxylin and iron alum, safranin and gentian violet, and cyanin and erythrosin. The first and second combinations were especially successful. The safranin and gentian violet was especially good for demonstrating the antipodals. A large number of slides were prepared and most of the points figured were observed many times.

Development of the Megaspore and Embryo-sac

The archesporial cell develops from the hypodermis and is easily distinguished from the surrounding cells. In one instance two archesporial cells were observed. The archesporial cell enlarges (*fig. 1*) and the first tapetal cell is formed by a transverse division (*fig. 2*). Other tapetal cells are formed in a very irregular manner as a result of the division of the first. Two

* Contributions from the Botanical Laboratory, Ohio State University.

tapetal cells may be formed by a periclinal wall (*f. 3*) or by an anticlinal wall (*f. 4*) or three may be formed by the formation first of an anticlinal wall followed by a periclinal wall in one cell only, or four may be formed by two periclinal walls followed by one anticlinal in one cell only, or by one anticlinal wall followed by two periclinal walls (*f. 5*).

The formation of the potential and the functional megaspores was not observed but many cases of the growth of the functional megaspore and degeneration of the potential megaspores were observed (*f. 6–9*). In one case two well-developed functional megaspores were observed lying side by side (*f. 10*).

The embryo-sac is perfectly straight and develops rapidly, enlarging principally in the direction of its longer axis, the greater growth being towards the micropyle at the expense of the tapetal cells (*f. 11–13*). An abundance of starch usually appears in the developed megaspore and persists throughout the two- and four-celled stages (*f. 9, 11, 12*). The antipodal cells are very small and disappear about the time of the conjugation of the polar nuclei (*f. 13*). In only one instance were they observed to persist until the beginning of the formation of the endosperm.

With the formation of the endosperm nucleus the egg apparatus becomes very distinct (*f. 14, 15*). The synergids are quite apparent and at least one of them persists for a very long time (*f. 23, 28*).

Shortly after the conjugation of the polar nuclei (*f. 13, 14, 15*) and fertilization of the egg (*f. 16*) the endosperm nucleus divides and a very delicate but definite wall is formed across the sac (*f. 16, 17*) similar to that described by Schaffner for *Sagittaria* (**12**).

The upper nucleus thus formed moves toward the embryo and rapidly forms the endosperm (*f. 17* and *text fig. 1*). This end of the sac enlarges rapidly and becomes filled with endosperm (*f. 21*) which persists until the embryo is fully formed but the cell walls gradually become thinner and the protoplasm gradually disappears as the embryo approaches maturity.

The other cell formed by the division of the endosperm nucleus grows towards the chalazal end of the ovule, forming a tube by the absorption of the nucellus and leaving in its trail a long string of

protoplasm reaching back to the endosperm which never enters this tube (*f. 17, 18, 19* and *text fig. 1*). The formation of this tube is in the axis of the ovule, where the nucellus cells are slightly elongated and have very thin walls. These cells are absorbed very readily, the fragments along the sides of the tube usually being very few and very small. The nucleus reaches the chalazal end of the ovule about the time the embryo is in quadrant stage (*text*

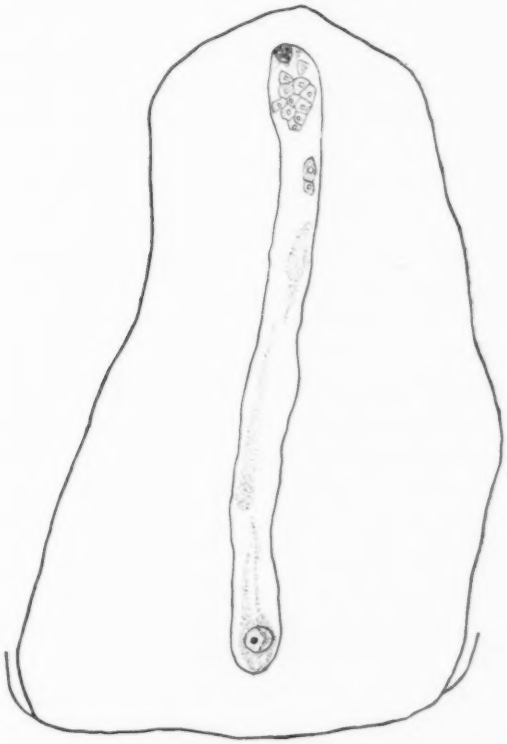

FIG. 1. Tube formed by lower endosperm nucleus. Three-celled embryo and endosperm in upper end of tube, lower endosperm nucleus in lower end of tube. Fig. 19 drawn from same section.

fig. 1). Upon reaching the chalazal end of the ovule the end of the tube enlarges, the cell making a corresponding enlargement and then degenerating (*f. 20, a, b*). This process is complete when the embryo and endosperm are in the stage represented by *f. 21.*

Hegelmaier, in his "Untersuchungen über die Morphologie der Dikotyledonen-Endosperms" (**7**), describes four types of endosperm development which he designates as: (1) "Allseitig-perisperme" (*e. g., Adonis, Caltha, Cotoneaster, Malva, Hibiscus*). (2) "Peripherisch-simultanen" (*e. g., Bocconia, Scabiosa,, Euphorbia*). (3) "Einseitig peripherischen" (*e. g., Trigonella, Phaseolus, Fagopyrum*). (4) "Endogene" (*e.g., Eranthis*). In the Nymphaeaceae we apparently have a type intermediate between the third and fourth with greater resemblance to the third type, but differing from it in the appearance and activity of the lower endosperm nucleus.

The physiological significance of this nucleus presents a very interesting problem which should be considered in connection with the function of the antipodals.

In the case of the Ranunculaceae as described by Coulter (**1**) the very large antipodals indicate some very important function which is emphasized by Campbell's study of *Sparganium simplex* (**5**) in which he describes a very great increase in the number of antipodal cells. Lloyd's researches on *Vaillantia hispida* (**10**) seem to throw some light on this problem. He describes the behavior of the antipodals, the third and lowest of which form a haustorium which projects back into the disintegrating megaspores and apparently bearing a nutritive relation to the embryo-sac. Guignard in his recent paper on *Naias major* (**6**) describes two of the antipodals degenerating and the upper one enlarging long after the fertilization of the öosphere.

Chamberlain in his paper on *Aster Novae-Angliae* (**3**) describes and figures a peculiar enlargement of the lower antipodal and believes that one of the nuclei represents an oösphere, thus emphasizing Strasburger's view that the antipodal region is homologous with the prothallium of the Gymnosperms.

Whatever may be the physiological or morphological significance of the antipodals in the plants to which we have just referred and whatever it may have been in the past we find many plants to which Strasburger's view cannot be applied.

In many cases the antipodals are very small and without function but we frequently find other structures which are apparently performing a similar function to that described by Lloyd for *Vaillantia hispida* (**10**). In *Lilium Philadelphicum* (**2**) Coulter de-

scribes an enlargement of the sac with the three disorganizing antipodals in a small caecum-like structure. Riddle (**11**) in her studies on *Alyssum macrocarpum* describes a decided enlargement of the sac, and an increase in the endosperm with a very pronounced accumulation of endosperm cells in the antipodal region, usually obscuring the antipodals which are very small and apparently functionless.

In Schaffner's studies of *Sagittaria variabilis* (**12**) we have a condition very nearly that found in the Nymphaeaceae. The endosperm nucleus divides and a wall is formed across the sac; the lower part of the sac does not enlarge greatly as in the Nymphaeaceae and the antipodals persist but the nuclei resemble very closely those I have described for the Nymphaeaceae.

We find further evidence on this point in the papers on *Potamogeton* by Wiegand (**15**) and by Holferty (**8**). Wiegand describes for *P. foliosus* (**15**) a sac of seven nuclei, three forming the egg apparatus and three the antipodals and one very large nucleus which he calls the fourth antipodal and states that a little later it divides into two and that a wall forms across the sac at this point, separating the two nuclei thus formed. He furthermore states that the upper of these two new nuclei divides forming the endosperm, the lower remaining undivided. Holferty describes *P. natans* (**8**) as forming the normal eight-celled sac and the polar nuclei as fusing in the normal manner.

From these two papers it seems possible that Wiegand failed to observe the conjugation of the polar nuclei and that the division of the fourth large antipodal was really a division of the endosperm nucleus as in *Sagittaria* and the Nymphaeaceae.

It seems unreasonable to suppose that the antipodals are without physiological significance in those plants where they are prominent. In the Ranunculaceae, in *Sparganium*, and in *Vaillantia* the antipodals appear to furnish nourishment for the embryo. The peculiar haustorial development of the antipodal of *Vaillantia*, the enlargement of the lower antipodal in *Aster*, the accumulation of endosperm in the antipodal region of *Alyssum*, and the large lower nucleus formed by a division of the endosperm nucleus in *Sagittaria* and the Nymphaeaceae show a resemblance which I believe indicates similar physiological functions. The mere enlarge-

ment of the sac of *Lilium* and many other plants may accomplish the same result by absorption of the surrounding cells of the nucellus.

A very pronounced sclerification was developed in the inner part of the epidermal cells just before maturity of the embryo-sac (*f. 6–9, 11–13, 16*). These cells separated readily from the underlying cells of the nucellus and from each other; often the microtome knife would tear them loose and pressure upon the cover-glass of a fresh preparation was usually sufficient to separate them. Although fertilization was observed but once (*f. 16*) and then the path of the pollen tube could not be traced, I am inclined to believe that it occurs in the usual manner.

DEVELOPMENT OF THE EMBRYO

The embryo becomes very prominent (*f. 16*) and divides by a transverse division which is usually oblique (*f. 22, 23*). This is followed by the formation of a quadrant (*f. 23*) and an octant (*f. 24*), the embryo retaining its spherical form. In one instance a distinct twelve-celled embryo (*f. 25*) was observed. The formation of the octant is not always regular and the divisions following this are very irregular, especially in *N. advena*, but the embryo retains its spherical condition until fully half developed and becomes free in the sac (*f. 26, 29*). The free spherical condition corresponds to the condition observed in *Nelumbo* by Lyon (**9**).

In one case polyembryony (*f. 27*) was observed and was apparently due to the splitting of a very young embryo, since the embryo may typically be said to have two or four basal cells, while in one case of polyembryony each embryo showed one distinct basal cell.

When well advanced there is an increased activity in the division of the cells on the side of the embryo farthest from the micropyle (*f. 29, c*). This is the first appearance of the cotyledon the growth being forward and lateral, the edges being slightly curved so as to form a sort of elongate tray with the main spherical part of the embryo placed at one end (*f. 30, 31*).

A few cells next to the micropyle, probably the original basal cells, show increased activity shortly after the first appearance of

the cotyledon growth and eventually forms the suspensor which projects towards the micropyle as a short cone-like organ, but does not become attached to the walls of the embryo-sac (*f. 29, s, 32, s*) and does not appear to be of any great value.

The cotyledon was not observed to bifurcate (*text fig. 2*), as Lyon describes for *Nelumbo* (9), although embryos older than

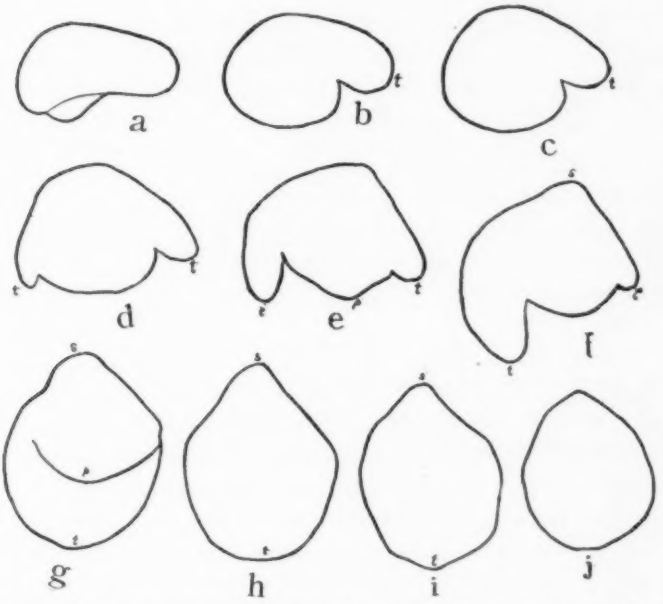

FIG. 2. Outline drawings from series of sections of single embryo of *N. advena* showing relation of parts. *s*, suspensor; *p*, plumule; *t*, cotyledon.

those figured were examined. Soon after the appearance of the suspensor there is an increased activity of the remaining spherical part of the embryo, resulting in the formation of a plumule (*f. 31, plum.*). This agrees with *Nelumbo* (9) as described by Lyon. The primary root is formed by an increased activity of cells between the suspensor and plumule (*f. 31, r*) and also agrees with *Nelumbo* as described by Lyon.

The embryo in its development cannot be said to show a marked resemblance to any of the monocotyledonous plants to which we might suppose it to be related. Aside from the suspensor it compares fairly well with *Lilium* and *Erythronium*. How-

ever, the development of the embryo-sac bears a striking resemblance to *Potamogeton*, *Naias*, and *Sagittaria*. The formation of tapetal cells and of megaspores is very similar to that described by Holferty for *Potamogeton* (8) and Campbell for *Naias* (4). The first division of the definitive nucleus and the formation of the wall across the sac is the same as observed by Schaffner in *Sagittaria* (12).

Lyon concludes that the Nymphaeaceae should be classified among the Monocotyledons in the series Helobiae (Naiadales). Van Tieghem in "Elements de Botanique" (14) makes a special class including the Nymphaeaceae and Gramineae between the Monocotyledons and the Dicotyledons which he calls "Liorhizes Dicotylees." Taking into consideration the general anatomy and habits of the plants, and the fact that the formation of a lower endosperm nucleus is similar to *Sagittaria* (12), it appears that the Nymphaeaceae should be placed in or near the order Naiadales.

SUMMARY

1. The archesporial cell is hypodermal.

2. The formation of the tapetal cells is irregular.

3. The formation of the megaspores is after the usual manner.

4. The embryo-sac usually contains starch in the one-, two-, and four-celled stages.

5. The formation of the eight-celled embryo-sac is in the usual manner.

6. At least one of the synergids persists for a very long period.

7. The antipodals are very small and disappear early.

8. The endosperm nucleus divides and a wall is formed across the embryo-sac between the two nuclei. The upper forms true endosperm, the lower a tube extending to the chalazal end of the ovule for absorbing the cells of the nucellus.

9. The embryo is at first spherical and later forms a single cotyledon.

10. The suspensor is late in forming and apparently without function.

11. The family Nymphaeaceae should be placed in or near the order Naiadales.

The writer wishes to express his thanks to Professor J. M.

Coulter and Dr. Charles J. Chamberlain, of the University of Chicago, for valuable suggestions in the first part of the investigation, and to Professor J. H. Schaffner, of the Ohio State University, for very valuable assistance in the later studies.

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Explanation of Plates

PLATE 12

Castalia odorata (except Fig. 16 which is *C. Zanzibariensis*).

FIG. 1. One archesporial cell.

FIG. 2. One archesporial cell and one tapetal cell formed by a periclinal wall.

FIG. 3. Archesporial cell and two tapetal cells formed by periclinal wall.

FIG. 4. Archesporial cell and two tapetal cells formed by anticlinal wall.

FIG. 5. Archesporial cell and four tapetal cells.

FIG. 6. Functional megaspore and three dissolving megaspores and two tapetal cells

FIG. 7. Functional megaspore and dissolving megaspores and tapetal cells.

FIG. 8. Functional megaspore and dissolving macrospores and tapetal cells.

FIG. 9. Functional megaspore and dissolving megaspore and tapetal cells. Starch in functional megaspores.

FIG. 10. Two functional megaspores. (Missing nucleus was in next section.)

FIG. 11. Two-celled embryo-sac containing starch.

FIG. 12. Four-celled embryo-sac containing starch.

FIG. 13. Eight-celled embryo-sac Conjugating polar nuclei. Degenerating antipodals.

FIGS. 14, 15. Mature embryo-sac with egg apparatus and endosperm nuclei.

FIG. 16. Fertilized egg and pollen tube. First division of the endosperm nuclei. The two nuclei separated by a wall.

FIG. 17. Separation of the two nuclei after division of the definitive nucleus. Fertilized egg and one synergid.

FIG. 18. Lower nucleus formed by division of definitive nucleus about one-third way down ovule.

FIG. 19. Lower nucleus (from text figure 1).

FIG. 20*a*. Lower nucleus in the enlarged end of the tube. Nucleus degenerating.

FIG. 20*b*. Same as 27*a*.

PLATE 13

Nymphaea advena (except Figs. 21–24, which are *C. odorata*).

FIG. 21. Upper end of tube enlarged and containing embryo and endosperm. Age corresponds to Fig. 20.

FIG. 22. Embryo of three cells. One synergid.

FIG. 23. Embryo of four cells. One synergid.

FIG. 24. Embryo of eight cells.

FIG. 25. Embryo of twelve cells. (The other three cells were found in the next section.)

FIG. 26. Spherical embryo.

FIG. 27. Double embryo.

FIG. 28. Spherical embryo. One synergid.

FIG. 29. Spherical embryo showing beginning of cotyledon (*c*) and suspensor (*s*)

FIG. 30. Embryo showing spherical part of embryo and the cotyledon.

FIG. 31. Embryo showing cotyledon, two leaves of plumule (*plum.*) and root (*r*).

FIG. 32. Section from same embryo as 31 showing suspensor (*s*).

New and noteworthy Northwestern Plants—VI

By C. V. Piper

Antennaria Hendersoni sp. nov.

Loosely tufted, bearing at base ascending stolon-like branches 3–6 cm. long; whole plant covered with a closely matted white tomentum, which becoming slightly looser on the stem: flowering stems erect, 20–35 cm. high: basal leaves crowded, narrowly oblanceolate, not petioled, acute and often curved at tip, 15–30 mm. long, 3–4 mm. broad; cauline leaves scattered, linear-oblanceolate, acute, gradually reduced upward: heads numerous, rather loosely corymbed; involucre 5–6 mm. high, woolly below; bracts pale, sometimes slightly brownish at base, the white papery tips rather obtuse and somewhat lacerate, the inner ones twice as long as the outermost: pappus white.

Mt. Adams, Wash., Aug. 6, 1892, *L. F. Henderson, 2290* in part; pistillate plants only.

The species here proposed is clearly not referable to any hitherto recognized from the Cascade Mountains and does not agree with any described Rocky Mountain species. It is nearest perhaps to *A. nardina* Greene.

Antennaria leucophaea sp. nov.

Whole plant silvery with a closely appressed tomentum, apparently tufted, the woody base bearing leafy surculose stolons 3–4 cm. long: flowering stems leafy to the inflorescence, erect, 8–14 cm. high: leaves numerous, sessile, linear or linear-oblanceolate, acute, 2–5 cm. long, the lowest with broader somewhat scarious partly sheathing bases: heads in a single dense cluster or corymbed: involucre oblong-cylindric, woolly only at the base, 5–7 mm. high; bracts in several series, linear-lanceolate, acute or acutish, scarious, brownish except the white tips: pappus white: male plant unknown.

Klickitat, Wash., May 15, 1882, *Thomas Howell* (type); Little Klickitat Valley, Wash., May, 1880, *Suksdorf, 283*. (The locality and number of the Suksdorf specimen are open to question as it is mounted with specimens of *A. lanata* Greene, the one label being apparently a combination of two original ones.) Both collections are in the Gray Herbarium.

In the Synoptical Flora the Howell specimen was referred to *A. luzuloides* T. & G. from which the brown involucre and stoloniferous habit clearly separate it. It is probably nearest *A. stenophylla* Gray but is larger in every way besides being stoloniferous.

Madia ramosa sp. nov.

Annual, erect, 25–30 cm. high, loosely branched above, finely hirsute throughout, stipitate-glandular except at the base: leaves few, alternate, or the lowest opposite, only 2–5 pairs below the inflorescence, all sessile, linear, acute, 2–4 cm. long: inflorescence a loose cyme: heads solitary and lateral or 2–4 in terminal clusters, the lateral heads sessile or nearly so; heads oblong or narrowly ovate, flattened, 7–10 mm. long: disk-flowers 1–4, yellow; ray-flowers wanting, rarely 1–2, the ligule very short: akenes 5 mm. long, curved, broadest near the apex, mostly carinate on one face.

Blue Mts., Walla Walla county, Wash., *Piper, 2451*, Aug. 2, 1896 (type).

Sterile mountain ridges 5,000 ft. alt. Eastern Oregon, *Cusick, 1789*, Aug., 1897.

A close ally of *M. glomerata* Hook., differing essentially in its much smaller size, glandular pubescence, sparse leafiness and loose inflorescence.

CACALIOPSIS NARDOSMIA **glabrata** var. nov.

Differs from the typical form as follows: leaves larger, 10–60 cm. in diameter, green above from the first, at length becoming glabrous beneath also: petioles relatively longer, 20–60 cm. long: heads smaller, less than 20 mm. high (20–25 mm. in the type): corolla shorter, about 15 mm. long; corolla-lobes proportionately longer, one half the length of the broader part of the tube (only one fourth the length of the broad part of the tube in the type): akenes 4 mm. long (4–7 mm. in the type).

The types of *C. nardosmia* Gray are from Sonoma, Humboldt and Mendocino counties, California. All of the Washington specimens differ from the Californian in the particulars pointed out. No specimens have been seen from Oregon.

Klickitat county, *Suksdorf*, 1883 (type in the Gray Herbarium). Klickitat River, *Flett, 1104*. Simcoe Mts., Howell. Stevens Pass, *Sandberg & Leiberg, 564*. Roslyn, *Whited, 425*. Without locality, *Vasey, 252*.

MENTHA ARVENSIS **lanata** var. nov.

Size and habits of var. *Canadensis* Briquet (*M. Canadensis* L.), but the calyx, stem, petioles and often the whole under side of the leaf-blade densely lanate-pubescent.

Specimens examined:

WASHINGTON: Parrotts P. O., *Lake & Hull, 603*, Aug. 5, 1892 (type in the Gray Herbarium). Wilson Creek, *Lake & Hull*, Aug. 5, 1892.

IDAHO: Kootenai county, *J. H. Sandberg*. Mud Lake, Kootenai county, *Sandberg, MacDougal & Heller, 734*. "Fort Colville to Rocky Mts.," *Lyall* in 1861.

CALIFORNIA: Santa Barbara, Sept., 1882, *Mrs. R. F. Bingham;* Clear Lake, Aug. 16, 1882, *Pringle*.

Synthyris schizantha sp. nov.

Rootstocks short, creeping: radical leaves reniform-orbicular, 5–7-nerved, indistinctly lobed, doubly dentate, glabrous above, pubescent beneath, especially on the veins, 5–12 cm. broad; petioles exceeding the blades, pubescent: flowering stem pubescent, 20–25 cm. high, bearing a pair of nearly sessile ovate-orbicular leaves, 2–3 cm. long, just below the inflorescence: raceme 4–6 cm. long in flower, rather dense, viscidly pubescent; bracts lanceolate, entire or the lower ones laciniately few toothed at apex, 5–8 mm. in length, about as long as the pedicels: calyx-lobes subequal, lanceolate and entire, or those of the lower flowers often toothed or even laciniately cleft: corolla blue, 5–6 mm. long, the subequal lobes all deeply cleft into narrow divisions: ovules about 3 in each cell: fruit not seen.

Baldy Peak, Olympic Mts., Wash., July 24, 1897, *Frank N. Lamb, 1343*.

A handsome species nearest related to *S. reniformis* Benth. The pubescence is apparently clammy viscid. On account of the peculiar corolla, some slight modifications in the generic characters are necessitated.

LOMATIUM MACROCARPUM **artemisiarum** var. nov.

Differs from the type essentially in its pubescence but otherwise quite as variable. In the typical form the pubescence is tomentose, especially in the inflorescence. In the variety here proposed there is no trace of this tomentose character, the plant being everywhere puberulent with short erect hairs.

This is the common form in the sage-brush of the Columbia Valley. The following specimens have been examined, all from Washington: Pasco, *Piper, 2976*, May 26, 1899 (type). North Yakima, *Henderson, 2509, 2511, 2574*, all collected May 25, 1892, Prosser, *Henderson, 2510*, May 26, 1892. Crab Creek, *Sandberg & Leiberg, 243*, June 19, 1893. Without locality, *Vasey, 308*.

The Vasey specimen is about 40 cm. tall with carpels 20–24 mm. long; the other specimens are 10–20 cm. tall with carpels 10–12 mm. long.

LOMATIUM MACROCARPUM **semivittatum** var. nov.

Ultimate leaf segments very narrowly linear or filiform: fruit narrowly winged, the dorsal ridges low; no oil-tubes on the dorsal side, 2–6 on the commissural side.

OREGON: Hood River, May 24, 1886 and Aug. 6, 1883, *Henderson, 397* (type); Hood River, *Mrs. Barrett, 71*.

WASHINGTON: West Klickitat County, *Suksdorf, 279*.

This form differs from *L. macrocarpum* essentially as above. It may be a distinct species as all of the specimens of the typical form or of the preceding variety that we have examined have dorsal oil tubes. The Henderson specimens were referred by Coulter and Rose to *P. bicolor* Wats. in the Revision of the North American Umbelliferae. It resembles that species only in foliage.

Astragalus Whitedii sp. nov.

Hoary pubescent throughout, the erect or ascending stems 40–50 cm. high, simple or sparingly branched: leaflets 5–7 pairs, oblong or obovate, truncate or emarginate at apex, acute at the nearly sessile base, 5–10 mm. long, the pubescence similar on both faces; stipules small: peduncles mostly exceeding the leaves: racemes short, few (5–7)-flowered: calyx cylindric campanulate, the pubescence blackish, the short teeth one fourth as long as the tube: corolla yellowish-white, twice as long as the calyx: pods linear, cartilaginous, 1-celled without sutural intrusions, 2.5–3 cm. long, acute, rather turgid, sparsely pubescent, curved into a semicircle, the stipe-like base as long as the calyx.

Colockum Creek, twenty miles southeast of Wenatchee, Wash., May 17, 1901, *K. Whited, 1353*; also young flowering specimens from the same station, collected in 1899.

An interesting new species of the § *Polo-sclerocarpus*, nearest related to *A. speirocarpus* Gray and *A. Gibbsii* Kell. It is a pleasure to name it after its enthusiastic discoverer.

ASTRAGALUS CYRTOIDES Gray, Proc. Am. Acad. **6**: 201

A careful examination of the type of this plant, collected on the Clearwater River, Idaho, by Spalding, shows it to be without question *A. collinus* Dougl. and not *A. Gibbsii* Kellogg. The specimens are in young flower.

The fruiting specimens from Carson City, Nevada, *Anderson*, which Dr. Gray referred in Proc. Am. Acad. **6**: 525 to his *A. cyrtoides*, are true *A. Gibbsii* Kell.

Philadelphus confusus sp. nov.

P. Gordonianus Bot. Calif. Not Lindley.

Shrub, 2–4 m. high, much branched above; bark pale, flaky: leaves ovate, acute or acuminate, rather thin, dentate or rarely entire, sparsely pubescent, 2–5 cm. long; petioles short: panicles 4–10-flowered, the lower one or two pairs of flowers in the axils of ordinary leaves: flowers odorous: calyx-lobes triangular-ovate, acute or acuminate, not twice as long as the tube, pubescent on the tips and margins within: petals pure white, oblong, 1.5–2 cm. long: styles united for two-thirds their length: stigmas rather broadly dilated: pods rather more than half inferior.

The common *Philadelphus* occurring from northern California to British Columbia west of the Cascade Mts. We have seen only two specimens from east of the Cascade Mts. that we would refer to *P. confusus*, namely: *Sandberg, Heller & MacDougal, 253*, Hatwai Creek, Idaho; *H. E. Brown*, July 16, 1896, Cañon City, Oregon.

As the type of *P. confusus* we would designate *Allen, 221*, collected on Tum Tum Mountain, Wash., Aug. 13, and Sept. 17, 1896.

The species differs from *P. Lewisii* Pursh essentially in its relatively shorter calyx-lobes, and the styles being united for two-thirds their length, whereas in *P. Lewisii* they are united only half their length.

P. Gordonianus Lindley is a synonym of *P. Lewisii* as indicated not only by Lindley's figure and description but by authentic

cultivated specimens from Lindley in the Gray Herbarium. The type was grown from seeds collected by Douglas "along the banks of the Columbia."

Douglas, however, collected *P. Lewisii* also as shown by a specimen in Herb. Gray. There can be no doubt as to the identity of *P. Lewisii* as the type in the herbarium of the Philadelphia Academy is in fine preservation. It was collected by Lewis, "on the waters of Clark's River," July 4, 1806. Dr. Elliott Coues says this means "Hellgate River, between Missoula, Mont., and the mouth of Big Blackfoot River, in Missoula county, Montana."

P. Lewisii ranges from the east slope of the Cascade Mts. of Oregon, Washington and British Columbia eastward to western Montana. We have not seen any specimen of it from west of the Cascade Mountains.

New Species of Uredineae—II

By J. C. Arthur

The following species of Uredineae have come to light, for the most part, from material kindly sent me by various collectors and students. In some cases they proved to be entirely unrepresented in my herbarium, but in other cases they had been known for some time, yet in too fragmentary condition to permit of description. Collections of what appear to be common species but upon unusual hosts often prove, when studied in connection with large series, to be new or otherwise interesting forms. Collections from previously unexplored regions generally well repay careful study, even if at first sight they seem to contain nothing new. All the species of this paper, except one from India, are from various parts of the United States. Thanks are due and are hereby extended to the several persons who contributed the material herein cited, as well as other material used for comparison during the study.

Uromyces Rickerianus sp. nov.

I. Aecidia more hypophyllous than epiphyllous, in dense clusters; substratum scarcely thickened; peridia pale, low, erose; aecidiospores globose to oblong, 16–22 × 18–26 μ; wall thin, minutely verrucose, appearing smooth.

III. Teleutosori at first intermixed with the aecidia, especially on the petioles, elliptical, reaching 4 mm. in length, long covered by the delicate, gray epidermis, at length pulverulent, chocolate-brown; teleutospores dark brown, globose to oblong, somewhat irregular, 20–25 × 23–35 μ, wall medium thick, apex not noticeably thickened, both apex and base rounded, pedicel colorless, fragile, very short.

On leaves of *Rumex Geyeri* (Meisn.) Trel., Teton Pass, Wy., July 13, 1901 (*Elmer D. Merrill* and *E. N. Wilcox*, no. 1217, comm. by P. L. Ricker).

The aecidia of this species bear a striking resemblance to those of *Puccinia phragmitis*, but have a little thinner and smoother wall, and are a trifle smaller; the gross appearance is about the same. The species is named in recognition of the interest taken

in plant rusts by Mr. P. L. Ricker, of the Bureau of Plant Industry, Washington, D. C., who has listed the Uredineae of Maine, and is now studying collections from the western United States.

Uromyces rottboelliae sp. nov.

X. Amphisori hypophyllous, oblong, prominent, soon naked, chestnut-brown, ruptured epidermis noticeable; amphispores obovate-globose, 18–25 × 25–30 μ, wall thick, 3 μ, golden brown, finely and closely tuberculate, pores 4, equatorial, pedicel colorless, delicate, about the length of the spore, semi-persistent.

III. Teleutospores globoid, of about the size and color of the amphispores, side wall about 2 μ thick, apex much thickened (8 μ), broad and almost truncate, base rounded, pedicel colorless, delicate, about the length of the spore, persistent.

On *Rottboellia speciosa* Hack. Jaunsar, Northwest Himalayas, India, 7,000 ft. alt., October, 1894 (*J. F. Duthie*, comm. by P. L. Ricker). This species was detected upon specimens in the phanerogamic herbarium of the U. S. Department of Agriculture by Mr. P. L. Ricker. It is notable for being the first Old World species observed possessing amphispores, so far as the writer knows. The amphisori have the gross appearance of teleutosori, the spores being dark colored and persistent. True uredospores were not seen, unless a few spores from parasitized sori were such; they differed from the amphispores only in having thin, yellow walls. Nor were teleutosori seen, the spores described being scattering ones from amphisori. In North America amphispores are known in *Puccinia vexans* Farl., and in a number of other species, but in none belonging to the genus *Uromyces*.

Puccinia tosta sp. nov.

O, I. Spermogonia and aecidia unknown.

II. Uredosori amphigenous, small, brownish yellow, soon naked, ruptured epidermis inconspicuous; uredospores globose, 20–30 μ in diameter, wall brownish yellow, thin, about 1.5 μ, closely and minutely tuberculate, pores 6 or more, scattered.

III. Teleutosori amphigenous, prominent, round or oblong, blackish brown, early naked, ruptured epidermis not visible; teleutospores globoid to oblong, 20–30 × 30–40 μ, rounded at both ends, slightly if at all constricted, side walls medium thick, apex thickened, 5–10 μ, pedicel thick, firm, tinted, once to twice the length of the spore, or longer.

On leaves and sheaths of *Sporobolus cuspida'us* (Torr.) Wood, Spirit Lake, Iowa, March, 1884 (*J. C. Arthur*), which is taken as the type, Aberdeen, S. D., Sept. 7, 1897 (*David Griffiths*), and Callaway, Neb., Oct. 2, 1901 (*J. M. Bates*, no. 2028). Also on *Sporobolus utilus* Torr., Las Vegas, N. M., Oct. 5, 1901 (*T. D. A. Cockerell*, comm. F. S. Earle), and Cochise, Ariz., Oct., 1900 (*David Griffiths*), and on *Sporobolus asperifolius* (N. & M.) Thurb., Billings, Mont., Aug., 1898 (*Williams & Griffiths*, comm. David Griffiths).

A rather common species in the semi-arid parts of the West, heretofore confused with other species of *Puccinia* on *Sporobolus*, more particularly with *P. sporoboli* Arth. The teleutospores are much shorter and more rounded than in *P. cryptandri* E. & B. and *P. vilfae* A. & H., and much shorter, broader, and the two cells more nearly equal in size than in *P. sporoboli* Arth. The uredospores of the four species are even more unlike, and are readily distinguished. In *P. sporoboli* they are echinulate, pores more than 4 and scattered; in *P. cryptandri* they are echinulate with 4 equatorial pores; in *P. vilfae* they are tuberculate, with wall colorless, apex thickened and pores obscure; and in *P. tosta* they are tuberculate with wall colored, pores more than 4 and scattered. The form on *S. asperifolius* is somewhat divergent, but not markedly so in the specimen examined. The host of the two specimens recorded as on *S. utilus* is sometimes called *S. repens* Presl., but it is possible that neither name is correctly used for this grass, a very common form in the Southwest.

Puccinia tosta luxurians var. nov.

II. Uredospores slightly larger than in the species, more strongly tuberculate, almost echinulate, wall thicker, about 2 μ.

III. Teleutosori elongated, in part linear with acute ends; teleutospores larger, oblong, 27–32 × 43–55 μ.

On *Sporobolus airoides* Torr., Andrews, Ore., Aug., 1901 (*Griffiths & Morris*, comm. David Griffiths), which is taken as the type, and on same host, Billings, Mont., Sept., 1898 (*Williams & Griffiths*, comm. David Griffiths). In both gross and minute characters this form on *S. airoides* differs somewhat from the previously described species, but for the most part the differ-

ences appear to be what might come from a more luxuriant development. Nevertheless the degree and uniformity of divergence make it seem the better course to keep this form by itself for the present. The wisdom of the course will be shown when a larger series of specimens can be examined and cultures made.

Puccinia aspera Dietel & Holway, sp. nov.

III. Sporen auf beiden Seiten der Blätter und an den Blattstielen, bisweilen Verkrümmungen hervorbringend, rundlich, gross, nackt, pulverig, kastanienbraun; Teleutosporen elliptisch oder oblong, in der Mitte schwach eingeschnurt, an beiden Enden abgerundet, an der Basis bisweilen verschmälert; Epispor am Scheitel nicht oder nur wenig verdickt, gelbbraun, von groben unregelmässigen Warzen rauh, 30–42 × 18–24 μ; Stiel hinfällig.

On *Saxifraga Mertensiana* Bong., Mt. Paddo, Wash., 7,000 ft. alt., Aug. 17, 1897 (*W. N. Suksdorf*, no. 537). This species resembles *Puccinia Jueliana* Diet., but has much larger and more pulverulent sori, and somewhat larger and slightly rougher spores. The description and part of the type specimen were transmitted to the writer by the authors of the species.

Puccinia turrita sp. nov.

III. Teleutosori amphigenous, rounded, .5–1 μ in diameter, early naked, chestnut brown; teleutospores elliptical or oblong, slightly abstricted, 20–24 × 37–48 μ, base rounded, apex acute or obtuse, very coarsely and irregularly tuberculate, especially at the apex, pedicel delicate, fugacious.

On *Saxifraga bronchialis* L., Manitou, Colo., Aug. 13, 1888 (*E. W. D. Holway*). The spores of this species are much rougher than those of *P. aspera* D. & H.; they remind one of the roughness of the teleutospores of *Phragmidium subcorticium* Wint. The four saxifrage species, *Puccinia Pazschkei* Diet., *P. Jueliana* Diet., *P. aspera* D. & H., and *P. turrita*, form a series, the spores of all being nearly of the same size and general shape, but showing an increasing roughness of the surface, and shortening of the pedicel. They appear to be distinct species, however, and not merely variations of one form. The indications are that all four species are without aecidia and uredospores, but this can not be stated positively.

Puccinia adenostegiae sp. nov.

III. Teleutosori caulinicolous, round or united into effused masses, early naked, cinnamon-brown, ruptured epidermis inconspicuous; teleutospores oblong, 15–22 × 45–67 μ, slightly constricted at the middle, apex obtuse, acute or sometimes acuminate, much thickened, base scarcely narrowed, side walls thin, pedicel delicate, somewhat tinted, as long as the spore or shorter.

On *Adenostegia pilosa* (A. Gray) Greene (*Cordylanthus pilosus* Gray), foothills near Stanford, Cal., Jan. 1, 1902 (*LeRoy Abrams*, comm. F. S. Earle). As many as three fourths of the spores in this collection, which was made in mid-winter, and therefore on dead stems, had germinated. The species appears to belong to the leptopuccinia group.

Uredo panici sp. nov.

Chiefly hypophyllous; sori oblong, intercostal, brownish yellow, early naked, ruptured epidermis inconspicuous; spores oval or globoid, 24–28 × 26–37 μ, wall thin, golden yellow, closely and conspicuously echinulate, pores more than 4, scattered.

On *Panicum amarum* Ell., Longboat Key, Fla., April 27, 1900 (*S. M. Tracy*, no. 6598), on Hog Island, Fla., Nov. 26, 1901 (*S. M. Tracy*, no. 7292, comm. F. S. Earle). The latter collection, which is accompanied by flowers of the host, is taken as the type. This uredo from its general appearance undoubtedly belongs to some *Puccinia* or *Uromyces*, although not a teleutospore could be discovered. The spores are larger than in any North American species inhabiting *Panicum* now known; the size of the spores, character of the surface, and arrangement of the pores, easily distinguish it.

Uredo cephalanthi sp. nov.

Sori mostly hypophyllous, small, irregularly bullate, distributed without order, pale, long covered by the epidermis; spores small, at first pedicellate, obovate-globose, 16–20 × 20–26 μ, wall thin, about 1 μ, closely and minutely echinulate, pores obscure, seemingly 4 and equatorial.

On *Cephalanthus occidentalis* L., Palmetto, Fla., Nov. 30, 1901 (*S. M. Tracy*, no. 7288, comm. F. S. Earle).

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Studies on the Rocky Mountain Flora—VIII

By Per Axel Rydberg.

Stanleya arcuata sp. nov.

Perennial with a ligneous caudex, 4–10 dm. high, perfectly glabrous; stem light green and shining, in age straw-colored: leaves entire or the lower with short and broad lobes, lanceolate, long-petioled, thick, 5–12 cm. long; pedicels rather short, in fruit, about 1 cm. long: sepals yellow, linear about 15 mm. long; petals yellow; blades 7–8 mm. long, broadly elliptic, almost as long as or at least two thirds as long as the claw: pods 7–10 cm. long, strongly arcuate, and spreading.

This species is nearest related to *S. integrifolia*, but is taller, more shrubby, with narrower leaves and broader petals. *S. pinnata* (Pursh) Britton, with which both have been confused, has hairy leaves, most of which are deeply pinnatifid, and the blades of its petals are linear oblong and only one third or one half as long as the claws. *S. arcuata* grows in dry regions from Wyoming to Nevada and south to Colorado and Arizona; probably also in California.

Nevada: Unionville Valley, 1868, *S. Watson, 105* (type in herb. Columbia University).

Stanleya canescens sp. nov.

Stout perennial .5–1 m. high; stem light green, finely puberulent or glabrate, terete: leaves grayish puberulent, the upper entire and oblanceolate, 5–7 cm. long; the lower pinnatifid with oblong lateral lobes and a large oval or elliptic end-lobe: raceme dense, pedicels short, in fruit 1 cm. or less long, divergent: sepals linear, about 12 mm. long; blades of the yellow petals linear-oblong, about half as long as the claw: pods arcuate, spreading, 5–7 cm. long.

This is nearest related to the preceding, differing in the puberulent leaves, which are shorter and broader and more inclined to be pinnatifid.

Utah: Frisco, 1880, *M. E. Jones, 1809* (type in herb. N. Y. Bot. Garden).

Arizona: Fort Verde, 1887, *E. A. Mearns;* Verde River, 1883, *H. H. Rusby; Mexican Boundary Survey.*

Thelypodium macropetalum sp. nov.

A glabrous perennial, 4–6 dm. high: basal leaves oblanceolate or spatulate, short-petioled, 2–5 cm. long: lower stem-leaves oblong, obtuse, sessile, with rounded auricles at the base, 5–6 cm. long; upper leaves lanceolate-sagittate, acute; pedicels in fruit about 1 cm. long, divaricate: sepals about 5 mm, long, purplish with white margins; petals purple, spatulate, long-clawed, nearly three times as long as the sepals: pods 4–5 cm. long, ascending or erect and somewhat incurved.

This is related to *T. sagittatum* (Nutt.) Heller and *T. paniculatum* A. Nelson. From the former, it differs in the smaller leaves, the rounder auricles, the erect, not reflexed nor spreading pod; and from the latter by the much longer petals. It grows at an altitude of 1,000–1,200 m.

UTAH: Farmington, 1881, *M. E. Jones, 1841* (type in herb. N. Y. Bot. Garden).

IDAHO: Soda Springs, 1892, *Isabel Mulford.*

Thelypodium Utahense sp. nov.

Annual or biennial: stem 4–6 dm. high, sparingly pubescent below; leaves all lanceolate in outline, 5–10 cm. long, lanceolate, glabrous; segments broad and crowded, oblong-lanceolate to triangular: pedicels very short, in fruit scarcely more than 1 mm. long: sepals oblong, about 2 mm. long: petals spatulate, almost twice as long, white: pod about 3 cm. long, strongly reflexed.

This is probably nearest related to *S. reflexum* Nutt., which is decidedly hispid on the stem and the veins of the leaves and has much narrower leaf-segments. It grows at an altitude of about 600 m.

UTAH: St. George, 1880, *M. E. Jones* (type in herb. N. Y. Bot. Garden); 1877, *E. Palmer, 28.*

Lepidium Jonesii sp. nov.

Lepidium montanum var. *alyssoides* Jones, Zoe, **4**: 266. 1893. Not *L. alyssoides* A. Gray. 1849.

Perennial with a short woody caudex: stems 2–3 dm. high, glabrous, branched, glabrous: basal leaves pinnatifid with linear acute divisions; stem-leaves similar or the upper entire, narrowly linear: racemes rather short and dense; pedicels in fruit 6–8 mm. long, spreading: sepals oblanceolate, obtuse; petals white, much

exceeding the sepals; blade broadly obovate: pod acutish, oval in outline, about 4 mm. long and slightly over 2 mm. wide, glabrous, reticulate, only slightly wing-margined above, retuse; style about twice as long as the width of the wing margins.

This species is in some respects intermediate between *L. alyssoides* and *L. montanum*. In the former only the lowest leaves are pinnatifid, the pod is more rounded and the style is shorter, scarcely longer than the width of the wing-margin. It is closer related to *L. montanum*, differing mainly in the longer and narrower leaf-segments, having a more persistent base and being less pubescent.

UTAH: St. George, 1880, *M. E. Jones, 1636* (type in herb. N. Y. Bot. Garden); Price, 1900, *S. G. Stokes;* southern Utah, 1874, *C. C. Parry, 18*.

NEVADA: Trinity Mountains, 1868, *S. Watson, 120*.

Lepidium elongatum sp. nov.

Annual: stem branched near the base, about 3 dm. high, glandular pruinose above: basal leaves spatulate or oblanceolate, about 4 cm. long, coarsely toothed or somewhat pinnatifid with short lobes; stem leaves oblanceolate, tapering into a short petiole, entire or with a few small teeth, 3–4 cm. long, acutish: racemes elongated, at the ends of the branches, in fruit 1 dm. or more long: sepals oblong or oblanceolate, acute, thin and whitish; petals minute, linear-oblanceolate, one half to two thirds as long as the sepals or lacking: pods nearly orbicular, about 3 mm. broad, usually broadest a little above the middle, wing-margined and deeply retuse at the apex, glabrous or slightly pruinose: stigma sessile.

This species is nearest related to *L. apetalum* and *L. ramosissimum*. From the former it differs in the branching near the base, the more entire leaves, the somewhat larger pod and the petals which are generally present; and from the latter in the longer racemes, in the lack of the small axillary racemes characteristic to that species and a different pod. In *L. ramosissimum* this is broadest below the middle. *L. elongatum* grows on rocky hilltops.

WASHINGTON: Almata, 1896, *A. D. E. Elmer, 21* (type in herb. N. Y. Bot. Gard.).

IDAHO: About Lewiston, 1896, *A. A. & E. Gertrude Heller, 3008*.

Thlaspi Nuttallii

Thlaspi cochlcariforme Nutt. Journ. Acad. Phila. **7**: 13. 1834. Not DC. 1821.

This species has been merged in *T. alpestre*, but none of our American forms belong to that species. *T. Nuttallii* is intermediate between *T. parviflorum* A. Nelson and *T. glaucum* A. Nelson, having larger flowers than the former and smaller than the latter. The pod is obovate, rounded at the apex with a narrow sinus. In *T. glaucum* the sinus is broad and open.

Roripa clavata sp. nov.

Biennial, tall, perfectly glabrous: stem 6–10 dm. high, simple up to the inflorescence: leaves lyrate-pinnatifid, 5–10 cm. long, more or less auricled at the base; lobes 4–8 pairs, oblong to ovate, obtuse or acute, broadly dentate: inflorescence branched; petioles in fruit 5–10 mm. long, divaricate: petals spatulate, about 3 mm. long, exceeding the sepals: pod 10–12 mm. long, 2.5–3 mm. thick, decidedly clavate, obtuse, strongly curved; style nearly 1 mm. long.

This may have been included in Watson's *Nasturtium terrestre* var. *occidentale*; but the name *occidentale* cannot be used as there is already another older *Roripa occidentalis* Greene. It is not, however, *Roripa Pacifica* Howell, which is supposed to be a synonym of Watson's variety, for that species is described as being slightly pubescent and having pods which are acute at both ends, while in *R. clavata* the pod is almost truncate at the apex.

WASHINGTON: Hogeman, Chehalis county, 1897, *Frank H. Lamb, 1221* (type in herb. N. Y. Bot. Gard.); West Klickitat county, 1885, *W. M. Suksdorf*.

OREGON: Sauvie's Island, 1888, *T. Howell, 1333*.

BRITISH COLUMBIA: Port Henry, 1889, *John Macoun*.

IDAHO: Near Hope, Kootenai county, 1892, *Sandberg, MacDougal & Heller, 1029*, at least in part.

Roripa Underwoodii sp. nov.

Biennial, divaricately branched, even near the ground, perfectly glabrous; stems 2 dm. or more high: leaves 3–5 cm. long, lyrately pinnatifid, thin; lobes oblong, obtuse; the terminal one elliptic to broadly oval, sinuately toothed; petioles short, winged and

conspicuously auricled at the base: racemes numerous: pedicels short, in fruit scarcely more than 4 mm. long, diverging or even reflexed: sepals bright orange, obtuse; petals light yellow, scarcely equalling the sepals and not quite 1 mm. long: fruit (immature) 5–6 mm. long, slightly thicker at the base, abruptly contracted into a minute style, not .5 mm. long.

In general appearance, this species resembles most *R. palustris*, but it is more branched with divaricate branches, has much shorter pedicels, rather longer and more tapering pod and not half as long style. From *R. obtusa*, it differs in the shape of the leaves, which are less dissected, the shorter style and general habit. The type grew at an altitude of 3300 m.

COLORADO: Red Mountain, south of Ouray, 1901, *L. M. Underwood, 299a.*

Roripa integra sp. nov.

Biennial, glabrous: stems few, strict, branched above; basal leaves not seen as they are fallen off in the type specimen; stem-leaves spatulate or rhombic spatulate, 1–2 cm. long, not auricled at the base, entire or slightly sinuate: racemes slender, lax: petals 1.5 mm. long, scarcely exceeding the sepals; pedicels 1–3 mm. long, ascending: pod about 8 mm. long, somewhat curved: style about 5 mm. long.

The type specimen is labelled *Nasturtium palustre* var., but it is not closely related to this species. It is nearer *R. obtusa*, but differs in the entire leaves; the more tapering and more curved pod, the erect habit and the short style. It grows at an altitude of about 2700 m.

UTAH: Wasatch Mountains, 1869, *S. Watson, 64*, in part (type in herb. Columbia University).

Lesquerella arenosa (Richards).

Vesicaria arenosa Richardson, Frankl. Journ. App. 743.

Lesquerella Ludoviciana var. *arenosa* S. Wats. Proc. Am. Acad. **23**: 252.

This is amply distinct from *L. Ludoviciana* (DC.) S. Wats. or *L. argentea* (Pursh) MacM., by the more slender ascending stems, the shorter leaves, the oblanceolate, instead of linear stem-leaves and the comparatively larger and often somewhat ellipsoid pod. The range given in the Synoptical Flora should be extended to the Black Hills of South Dakota and northeastern Wyoming.

Lesquerella Shearis sp. nov.

Perennial with a large rosette of basal leaves; stems several, ascending, 1–2 dm. high, densely stellate: basal leaves 3–4 cm. long; blades broadly oval or ovate, entire or slightly angular denticulate; stem leaves oblanceolate, about 2 cm. long, subsessile: raceme many-flowered; pedicels in fruit bent S-shaped: pods erect, densely stellate, 7–8 mm. long, acute, compressed above; septum elliptic in outline: style about as long as the pod.

This species differs from *L. curvipes* A. Nelson in the broad basal leaves, the elliptic instead of ovate outline of the septum and the longer style. It grows along creek banks at an altitude of about 2000 m.

COLORADO: Idaho Springs, 1895, *C. L. Shear, 3269* (type in herb. N. Y. Bot. Gard.); also at the same locality, *P. A. Rydberg*.

Physaria brassicoides sp. nov.

A tufted perennial with a large and dense rosette of basal leaves and a thick taproot: basal leaves large, with winged petioles; blades almost orbicular in outline, sinuate-dentate, 2.5–5 cm. in diameter: stem leaves small and few, spatulate: flowering stems about 1 dm. high, ascending: flowers numerous: fruit almost obcordate, acute at the base, deeply divided above; cells inflated, rounded pyriform, 8–10 mm. long and 5–8 mm. in diameter: style about 5 mm. long.

This species resembles most *P. didymocarpa* in habit, but differs in the smaller fruit, which is not at all cordate at the base but on the contrary usually acute, and in the larger basal leaves which form a large rosette, 7–10 cm. in diameter and having some resemblance to a young cabbage-head. It grows in crevices of magnesian rocks in cañons and badlands.

NEBRASKA: Cañon south of Scott's Bluffs, 1891, *Rydberg*, 24.

Cardamine acuminata (Nutt.)

Cardamine hirsuta β acuminata Nutt.; T. & G. Fl. N. Am. 1: 85. 1838.

This species has been variously referred to *C. hirsuta*, *C. obligosperma*, and *C. Pennsylvanica*. It is probably nearest related to the last, but the lower part of the stem is hairy and the pod has an evident style over 1 mm. long. It ranges from the Mackenzie River to British Columbia, south to California and Wyoming.

conspicuously auricled at the base: racemes numerous: pedicels short, in fruit scarcely more than 4 mm. long, diverging or even reflexed: sepals bright orange, obtuse; petals light yellow, scarcely equalling the sepals and not quite 1 mm. long: fruit (immature) 5–6 mm. long, slightly thicker at the base, abruptly contracted into a minute style, not .5 mm. long.

In general appearance, this species resembles most *R. palustris*, but it is more branched with divaricate branches, has much shorter pedicels, rather longer and more tapering pod and not half as long style. From *R. obtusa*, it differs in the shape of the leaves, which are less dissected, the shorter style and general habit. The type grew at an altitude of 3300 m.

COLORADO: Red Mountain, south of Ouray, 1901, *L. M. Underwood, 299a.*

Roripa integra sp. nov.

Biennial, glabrous: stems few, strict, branched above; basal leaves not seen as they are fallen off in the type specimen; stem-leaves spatulate or rhombic spatulate, 1–2 cm. long, not auricled at the base, entire or slightly sinuate: racemes slender, lax: petals 1.5 mm. long, scarcely exceeding the sepals; pedicels 1–3 mm. long, ascending: pod about 8 mm. long, somewhat curved: style about 5 mm. long.

The type specimen is labelled *Nasturtium palustre* var., but it is not closely related to this species. It is nearer *R. obtusa*, but differs in the entire leaves; the more tapering and more curved pod, the erect habit and the short style. It grows at an altitude of about 2700 m.

UTAH: Wasatch Mountains, 1869, *S. Watson, 64*, in part (type in herb. Columbia University).

Lesquerella arenosa (Richards).

Vesicaria arenosa Richardson, Frankl. Journ. App. 743.

Lesquerella Ludoviciana var. *arenosa* S. Wats. Proc. Am. Acad. 23: 252.

This is amply distinct from *L. Ludoviciana* (DC.) S. Wats. or *L. argentea* (Pursh) MacM., by the more slender ascending stems, the shorter leaves, the oblanceolate, instead of linear stem-leaves and the comparatively larger and often somewhat ellipsoid pod. The range given in the Synoptical Flora should be extended to the Black Hills of South Dakota and northeastern Wyoming.

Lesquerella Shearis sp. nov.

Perennial with a large rosette of basal leaves; stems several, ascending, 1–2 dm. high, densely stellate: basal leaves 3–4 cm. long; blades broadly oval or ovate, entire or slightly angular denticulate; stem leaves oblanceolate, about 2 cm. long, subsessile: raceme many-flowered; pedicels in fruit bent S-shaped: pods erect, densely stellate, 7–8 mm. long, acute, compressed above; septum elliptic in outline: style about as long as the pod.

This species differs from *L. curvipes* A. Nelson in the broad basal leaves, the elliptic instead of ovate outline of the septum and the longer style. It grows along creek banks at an altitude of about 2000 m.

COLORADO: Idaho Springs, 1895, *C. L. Shear, 3269* (type in herb. N. Y. Bot. Gard.); also at the same locality, *P. A. Rydberg*.

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A tufted perennial with a large and dense rosette of basal leaves and a thick taproot: basal leaves large, with winged petioles; blades almost orbicular in outline, sinuate-dentate, 2.5–5 cm. in diameter: stem leaves small and few, spatulate: flowering stems about 1 dm. high, ascending: flowers numerous: fruit almost obcordate, acute at the base, deeply divided above; cells inflated, rounded pyriform, 8–10 mm. long and 5–8 mm. in diameter: style about 5 mm. long.

This species resembles most *P. didymocarpa* in habit, but differs in the smaller fruit, which is not at all cordate at the base but on the contrary usually acute, and in the larger basal leaves which form a large rosette, 7–10 cm. in diameter and having some resemblance to a young cabbage-head. It grows in crevices of magnesian rocks in cañons and badlands.

NEBRASKA: Cañon south of Scott's Bluffs, 1891, *Rydberg*, 24.

Cardamine acuminata (Nutt.)

Cardamine hirsuta β acuminata Nutt.; T. & G. Fl. N. Am. **1**: 85. 1838.

This species has been variously referred to *C. hirsuta*, *C. obligosperma*, and *C. Pennsylvanica*. It is probably nearest related to the last, but the lower part of the stem is hairy and the pod has an evident style over 1 mm. long. It ranges from the Mackenzie River to British Columbia, south to California and Wyoming.

Cardamine multifolia sp. nov.

Stem about 2 dm. high, very leafy, lower part hirsute: leaves 4–6 cm. long glabrous; leaflets 7–13, oblong to oblong-obovate or oval, entire or sinuate-dentate; the terminal one larger and obovate: flowers numerous: petals spatulate, about 2.5 mm. long; pedicels ascending, about 8 mm. long: pod erect, about 2 cm. long and .75 mm. wide.

This is perhaps closest related to *A. parvifolia* L., but is more leafy, has shorter and broader leaf-segments and erect pods, and the plant is less diffusely branched.

IDAHO: Beaver Cañon, 1895, *P. A. Rydberg.*

UTAH: Wasatch Mts., 1869, *S. Watson, 80*, in part.

Sophia brevipes (Nutt.)

Sisymbrium canescens ζ (*brevipes* Nutt. MSS.) Torr. & Gray, Fl. N. Am. 1: 92. 1838.

Sisymbrium Hartwegianum Fourn. Rech. Auct. & Tax. Fam. Cruc. & Gen. Sisymb. 66, in part. 1865.

Sisymbrium incisum var. *Hartwegianum* S. Wats. Bot. Calif. 1: 41.

The plant described by Dr. Watson in the Botany of California and by Dr. Robinson in the Synoptical Flora (p. 139) is I think without doubt the var. *brevipes* of Torrey and Gray's flora. Probably also Bourgeau's plant, cited by Fournier, belongs here; but I think that it is very doubtful that Hartweg's plant, which must be regarded as the type of *S. Hartwegianum* Fourn., could be the same.

Sophia Californica (T. & G.)

Sisymbrium canescens ε (*Californicum*) T. & G. Fl. N. Am. 1: 92. 1838.

This species is characterized by the large flowers, the sparingly stellate and often glandular-puberulent stem, the uniserial linear pod and once or twice pinnatifid leaves. The segments of the lower leaves are broad and obtuse, those of the upper linear to oblong. Its range extends from Montana to Washington south to California.

Sophia viscosa sp. nov.

Biennial, 5–10 dm. high: stem, at least the upper part, decidedly glandular or viscid-villous: leaves obovate or oblanceolate in out-

line, 3–10 cm. long, twice pinnatifid, densely pubescent; primary divisions of the lower leaves ovate and obtuse; those of the upper lanceolate and acute; secondary divisions oblong acute or obtuse, often few-toothed: inflorescence usually much branched; pedicels in fruit 8–12 mm. long: sepals yellowish, 1–15 mm. long, oblong; petals bright yellow, spatulate, about 2 mm. long: pod (in the specimens seen not fully developed) over 1 cm. long and less than 1 mm. wide: seeds uniserial.

This is perhaps nearest related to *S. incisa* (Engelm.) Greene; but differs in the dense viscid pubescence of the stem, the pubescent leaves and deeper divided primary segments. It grows among rocks and on grassy slopes.

IDAHO: Beaver Cañon, 1895, *C. L. Shear, 3029* (type in Herb. N. Y. Bot. Garden) and *3031*.

WYOMING: Trout Lake, 1899, *Aven & Elias Nelson, 5848*; Head of Pole Creek, 1895, *Aven Nelson, 1321*.

Sophia leptophylla sp. nov.

Stems 5–7 dm. high, sparingly glandular: leaves very thin, dark green, only once pinnate; segments of the lowest leaves rounded; those of the middle lanceolate and somewhat incised; the upper segments entire: pedicels slender, in fruit 5–8 mm. long, spreading: petals bright yellow, about 1.5 mm. long: pod linear, 8–10 mm. long, much less than 1 mm. wide, torulose, spreading, arcuate, curved up, uniserial.

This is nearest related to *S. incisa* (Engelm.) Greene, but differs in the less incised leaves and horizontal curved pod. It grows at an altitude of about 2000 m.

COLORADO: Foothills, Larimer county, 1895, *Crandall & Cowen, 55* (type in herb. N. Y. Bot. Gard.).

WYOMING: Antelope Basin, Albany county, 1900, *Aven Nelson, 7466*; Centennial Hills, 1895, *1686*.

Smelowskia Americana

Hutchinsia calycina Hook. Fl. Bor. Am. 1: 58. 1834. Not Desv. 1814.

Smelowskia calycina Gray, Proc. Acad. Philad. 1863: 58. Not C. A. Mey. 1831.

While in Europe last summer, I looked up the Asiatic type of *S. calycina*, and this differs considerably from ours especially in the long villous pubescence.

Draba brachystylis sp. nov.

Perennial with a taproot: stems several, decumbent or ascending with divergent branches, 1–1.5 dm. high, hirsute: basal leaves oblanceolate or spatulate, 1.5–2 cm. long, hirsute with branched hairs; stem leaves few, oblong or lanceolate, sessile: pedicels short, in fruit 2–5 mm. long, spreading: pod oblong, finely stellate, 8–12 mm. long, ascending: style very short, almost obsolete.

The type sheet of this species is labeled *Draba Carolina* var. *micrantha*, but the plant evidently is a perennial and nearest related to *D. streptocarpa*; but differs in the divergently branched stem, stellate pod and the almost obsolete style. It grows at an altitude of about 3000 m.

UTAH: Alta, Wasatch Mts., 1879, *M. E. Jones, 1357* (type in herb. N. Y. Bot. Gard.).

Draba decumbens sp. nov.

Perennial with a taproot, a short cespitose caudex and a large rosette of basal leaves: stems decumbent, 1–2 dm. high, sparingly pubescent, few-leaved; basal leaves broadly spatulate, entire, 2–4 cm. long, finely grayish stellate, rather thick; stem leaves ovate to ovate-lanceolate, sessile, entire, 1–2 cm. long: calyx sparingly villous; petals pale yellow, about 4 mm. long: pedicels very short, in fruit 2–4 mm. long: pod oblong, 8–15 mm. long, densely pubescent, usually twisted: style about 1 mm. long.

This is a member of the *D. aurea* group, and distinguished from all the North American species by its decumbent stems, large, thickish entire basal leaves.

COLORADO: Gray's Peak, 1895, *Rydberg* (type in herb. N. Y. Bot. Gard.).

Draba Macouniana sp. nov.

Annual, almost scapose: stems ascending or decumbent, less than 1 dm. high, glabrous and shining; basal leaves numerous, broadly spatulate or obovate, 5–10 mm. long, finely stellate, rather thick; stem leaf usually one, oval, obtuse, 5 mm. long: petioles in fruit spreading, 6–8 mm. long: petals white, less than 3 mm. long: pod oblong-linear, erect, about 1 cm. long and 2 mm. wide: style obsolete.

This species is nearest related to *D. crassifolia*, but differs in the whiter flowers, and the broad and short basal leaves, which are finely stellate, not hirsute ciliate. The type grew at an altitude of about 2000 m.

BRITISH COLUMBIA: Summit of Rocky Mountains, 1890, *John Macoun* (type in herb. Columbia University).

Draba Parryi sp. nov.

Annual, perfectly glabrous, except a few cilia on the petioles: stems several, usually less than 1 dm. high, scapiform or rarely with a stem leaf: basal leaves numerous, linear or narrowly linear-oblanceolate, 1.5–2.5 cm. long; pedicels spreading, in fruit 5–8 mm. long: flowers small; petals scarcely 2 mm. long, white or light yellow: pods erect, oblong, 5–8 mm. long, 1.5–2 mm. wide, glabrous: style obsolete.

This is closely related to *D. crassifolia* but the latter has broader leaves, which are more or less hirsute on the surface and distinctly ciliate on the margins.

COLORADO: Foot of Gray Peak, 1872, *E. L. Greene* (type in herb. Columbia University); 1872, *C. C. Parry;* Cameron Pass, 1896, *C. F. Baker.*

WYOMING: Telephone Mines, 1900, *Aven Nelson, 7879.*

Draba cana sp. nov.

Perennial with a taproot and short cespitose caudex, whole plant densely grayish stellate; stem 1–2 dm. high, often branched: basal leaves numerous, oblanceolate or spatulate, 1–1.5 cm. long, entire or minutely but sharply toothed, densely stellate; stem leaves lanceolate to ovate, about 1 cm. long: racemes many-flowered; pedicels short, nearly erect, in fruit 2–3 mm. long: flowers small; petals white, about 3 mm. long: pod linear-oblong, 6–8 mm. long, densely pubescent: style about 5 mm. long.

This has gone under the name of *D. incana,* but the latter is much less densely stellate and has a glabrous, much broader pod. I have seen only one specimen of true *D. incana* from this continent, and it was collected in Labrador. Most of those under this name belong to *D. cana,* which ranges from Labrador to the Yukon Territory, south in the mountains to Colorado. The following is regarded as the type.

ALBERTA: Morley, foothills of the Rocky Mountains, 1887, *John Macoun* (herb. Columbia University).

Draba McCallae sp. nov.

Perennial with a cespitose base, whole plant sparingly stellate but green: stems several, simple, about 3 dm. high: basal leaves

spatulate, 10–18 mm. long, entire or nearly so; stem leaves ovate, about 1 cm. long, sharply dentate or entire: raceme elongated; pedicels slender, in fruit about 1 cm. long, erect: petals white, 4–5 mm. long: pod (in the specimen not fully developed) ovate, densely but finely pubescent, much shorter than the pedicels: style 0.75 mm. long.

This species belongs also to the *D. incana* group, but differs from that species in the elongated peduncle, long pedicels, short pubescent pod and large petals.

Alberta: Valley below Mt. Aylmer, 1899, *W. C. McCalla, 2267* (type in herb. N. Y. Bot. Gard.).

Draba Columbiana sp. nov.

Perennial; with a cespitose base, sparingly and finely stellate and ciliate on the margin of the leaves: stems slender, about 2 dm. high, simple: basal leaves many, oblanceolate, 10–15 mm. long, denticulate or entire; stem leaves ovate to lanceolate, about 1 cm. long denticulate: raceme elongated, pedicels slender, ascending, 5–7 mm. long in fruit: flowers small; petals slightly over 2 mm. long, white: pods linear-oblong, finely pubescent, over 1 cm. long, style very short.

This species resembles much the preceding in habit, but the flowers are much smaller and the pods longer.

BRITISH COLUMBIA: Revelstoke, 1890, *John Macoun* (type in Herb. Columbia University).

Geranium Pattersonii sp. nov.

Cespitose perennial with a thick root and short caudex: stems ascending or diffuse, 2–4 dm. long, densely glandular villous with long spreading hairs, petioles of the basal leaves 5–10 cm. long, also glandular villous; blades reniform in outline, about 3 cm. broad, glandular villous on both sides, deeply 5–7-cleft; lobes broadly obovate-cuneate, 3-toothed; teeth broadly ovate, abruptly short-acuminate: stem leaves similar, but short-petioled or the uppermost subsessile: pedicels and calyx glandular long-villous; the former in fruit 1.5–2 cm. long: sepals in fruit about 8 mm. long, oval with a short bristle-tip about 1 mm. long: petals obovate about 1 cm. long, light purple, or rose color, with darker veins: style in fruit about 2 cm. long, glandular-pubescent; beak about 4 mm. long: carpels pubescent: seeds finely reticulate.

This species is perhaps nearest related to *G. Parryi* (Engelm.) Heller, but is lower, more densely glandular, has broader and

shorter lobes to the leaves and their teeth are broadly ovate, abruptly acuminate, instead of lanceolate. The general habit is perhaps more like *G. caespitosum* James, but in that species the lower part of the stem is grayish-pubescent with short reflexed hairs. *G. Pattersonii* is a subalpine plant growing at an altitude of 2500–3000 m.

COLORADO: Gray Peak, 1895, *P. A. Rydberg* (type in herb. N. Y. Bot. Gard.); foot of Pikes Peak, 1896, *C. L. Shear, 3702;* mountains, near Empire, 1892, *H. N. Patterson, 177* and *176* in part; North Cheyenne Cañon, 1896, *Ernest A. Bessey;* also 1845. *Freemont, 61.*

Geranium strigosum sp. nov.

Geranium Richardsonii Wats. King's Rep. 5: 49, in part. 1871. Not Fisch & May.

Erect perennial with a short thick rootstock: stem 4–8 dm. high, finely reflexed strigose; petioles of the basal leaves 2–5 dm. long, also sparingly strigose; blades reniform in outline, 7–12 cm. in diameter, finely strigose on both sides, deeply 7-cleft; divisions rhombic in outline, 3-cleft and toothed; teeth lanceolate, acute; stem leaves similar, but short-petioled; stipules linear-lanceolate, long-attenuate: inflorescence open, glandular pubescent: sepals densely glandular, oval, about 8 mm. long; bristle tips 1.5–2 mm. long; petals broadly obovate, rose color or light violet, strongly purple-veined: style in fruit about 3 cm. long, beak about 6 mm.: seeds reticulate.

This is nearest related to *G. viscosissimum*, but the corolla is lighter in color and the pubescence is different, being decidedly reflexed, strigose, not at all glandular, except on the inflorescence. It grows in the valleys to an altitude of perhaps 2700 m.

WYOMING: Copperton, 1901, *F. Tweedy, 4591* (type in herb. N. Y. Bot. Gard.); Big Horn Mountains, 1900, *3647.*

UTAH: City Creek Cañon, 1880, *M. E. Jones. 1871;* Parley's Cañon, 1901, *S. G. Stokes;* Black Rock and Uintahs, 1869, *S. Watson, 204.*

Oxalis Coloradensis sp. nov.

Perennial with a slender rootstock: stem slender, erect, 1–2 dm. high, sparingly villous; leaves digitately ternate; petioles 2–4 cm. long, sparingly villous: leaflets broadly obcordate, gla-

brous, 8–12 mm. long: peduncles very slender, about 5 cm. long: inflorescence cymose, but often reduced to 2–3 flowers; pedicels sparingly strigose: sepals 4–5 mm. long, oblong: petals yellow, 6–7 mm. long: pod cylindric with a conical apex, 12–15 mm. long, 2.5–3 mm. wide, glabrous.

This is nearest related to *O. cymosa* Small and *O. Brittoniae*, but differs from the former in the blunter sepals, the appressed pubescence of the pedicels and the glabrous pod, and from the latter in the simpler habit, the longer glabrous pod and paler and larger leaves. It grows in grassy valleys at an altitude of 1800–2500 m.

COLORADO: Sangre de Christo Creek, 1900, *Rydberg & Vreeland 5920* (type in herb. N. Y. Bot. Gard.); Foothills, Larimer county, 1895, *J. H. Cowen* (mixed with *O. stricta* L.).

Lupinus Scheuberae sp. nov.

Perennial; stem 4–6 dm. high, sparingly strigose or almost glabrous, slender: petioles of basal leaves about 1 dm. long; leaflets 7–8, oblanceolate, 5–7 cm. long, acute and mucronate, green, glabrous above, sparingly appressed pubescent beneath; stipules lanceolate, attenuate; stem leaves similar but shorter petioled: racemes 1–1.5 dm. long, not dense; bracts lanceolate, 7–8 mm. long, deciduous: flowers 10–12 mm. long: calyx densely white silvery puberulent, strongly gibbous above; lower lip lanceolate, fully twice as long as the triangular-ovate upper lip: corolla dark purple but lighter and almost white towards the base; banner slightly longer than the wings, silky puberulent on the middle of the back: pod densely white silky with appressed hairs, 2–4-seeded.

This is nearest related to *L. pseudoparviflorus*, but differs in the somewhat larger flowers, the strictly appressed white pubescence on the calyx and pedicels, the gibbous, but not spurred calyx, and the broad and short upper lip of the latter. It grows in woods at an altitude of 2,000–2,400 mm.

MONTANA: Garnet county, 1901, *Mrs. Emma Ware Sheuber, 135* (type in herb. N. Y. Bot. Gard.).

WYOMING: Copperton, 1901, *Frank Tweedy, 4216*.

Lupinus spathulatus sp. nov.

Lupinus parviflorus S. Wats. King's Rep. **5**: 1871. Not Nutt.

Perennial: stem 8–10 dm. high, glabrous or sparingly strigose above, leafy; stipules narrowly lanceolate, attenuate: petioles 3–5 cm. long; leaflets about 7, spatulate or broadly oblanceolate, about 4 cm. long, mucronate, those of the lower leaves obtuse, those of the upper more acute, glabrous above, finely puberulent beneath; raceme elongated, about 2 dm. long, many-flowered: flowers subverticillate; pedicels about .5 cm. long, as well as the calyx, pubescent with short spreading hairs; bracts lanceolate, attenuate, deciduous, longer than the buds; calyx gibbous at the base; lower lip lanceolate, about twice as long as the short ovate upper one: corolla dark blue, with lighter keel; banner glabrous, rounded and shorter than the wings.

This has been confused with *L. parviflorus*, which it closely resembles, differing mostly in the shape of the calyx; the lower lip in that species is only slightly longer than the upper and the banner is larger and less rounded. The type grew at an altitude of 2400 m.

UTAH: Wasatch Mountains, 1869, *S. Watson, 225* (type in herb. Columbia University).

Lupinus flavescens sp. nov.

Perennial: stem about 3 dm. high, appressed pubescent with rather long hairs: stipules lanceolate, densely hairy: petioles often over 1 dm. long, appressed silky; leaflets about 7, oblanceolate, 3–4 cm. long, appressed silky on both sides: inflorescence short; bracts lanceolate, early deciduous; pedicels 8–10 mm. long, as well as the calyx densely pubescent with short, spreading hairs: calyx gibbous at the base; its lips almost equal in length, both about 8 mm. long: corolla 12–14 mm. long, pale yellow; banner with a darker spot, glabrous.

The type has been known as *L. sulphureus* and was included therein questionably by Watson; but differs in the larger, paler flowers, and the longer lips of the calyx, and the longer pubescence.

IDAHO or MONTANA: Medicine Clay Prairies, *Wyeth* (type in herb. Columbia University).

Lupinus lucidulus sp. nov.

Perennial: stem 5–6 dm. high, branched above, finely silky strigose, especially the upper portions, leafy; stipules minute, ovate, acuminate: petioles 3–5 cm. long; leaflets 7–8, linear-oblanceo-

late, silky and silvery on both sides, about 3 cm. long: raceme 1–2 dm. long, lax: flowers scattered; pedicels and calyx densely pubescent with short strictly appressed silky hairs; lower lip of the calyx about 5 mm. long, lanceolate, almost twice as long as the short ovate upper one: corolla yellow or light pink; banner slightly exceeding the wings, with a few short hairs on the back, with a darker spot, about 8 mm. long: pods densely silky pubescent.

This species is nearest related to *L. sulphureus*, but differs in the more silvery pubescence, the smaller flowers and the appressed pubescence of the calyx and pedicels. The type grew at an altitude of 1900 m.

WYOMING: Spread Creek, 1897, *F. Tweedy, 271* (type in herb. N. Y. Bot. Garden).

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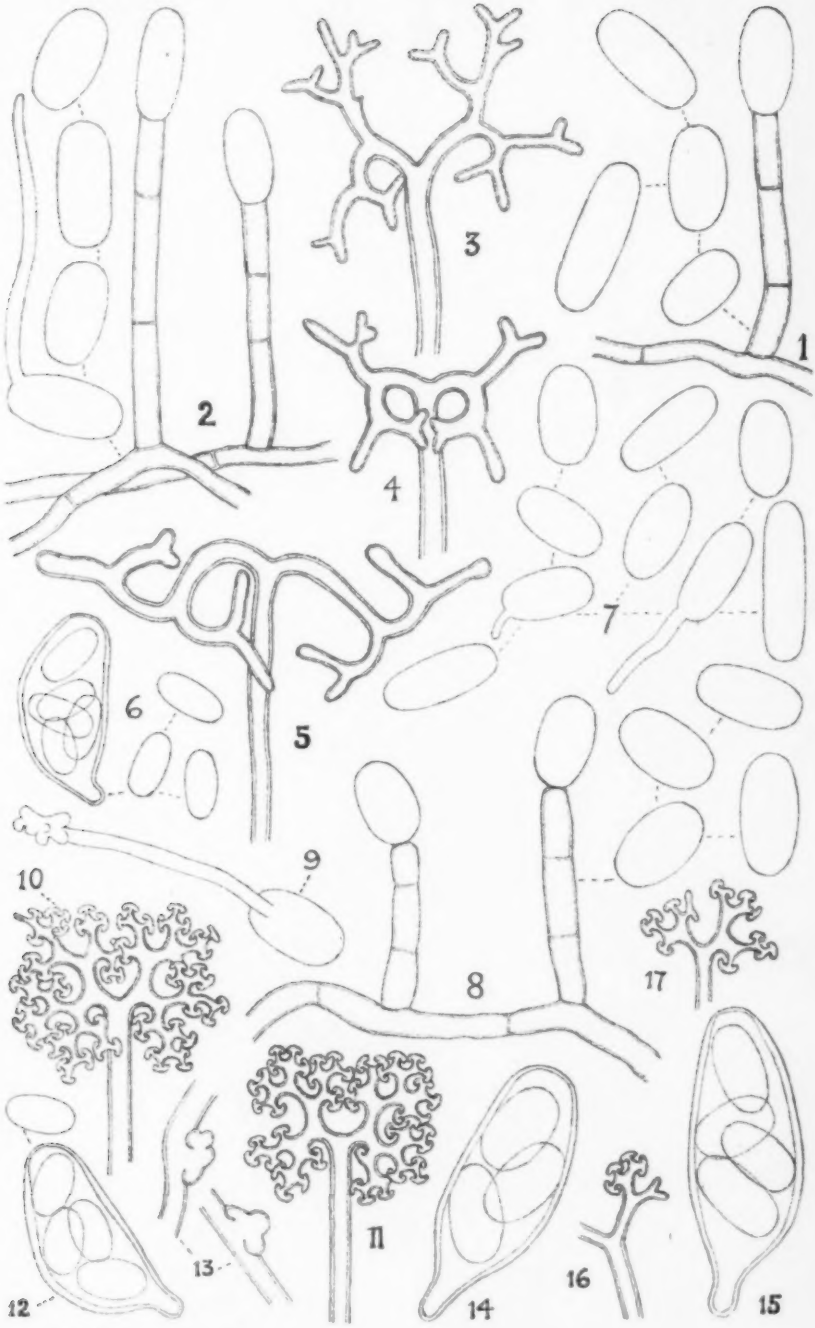

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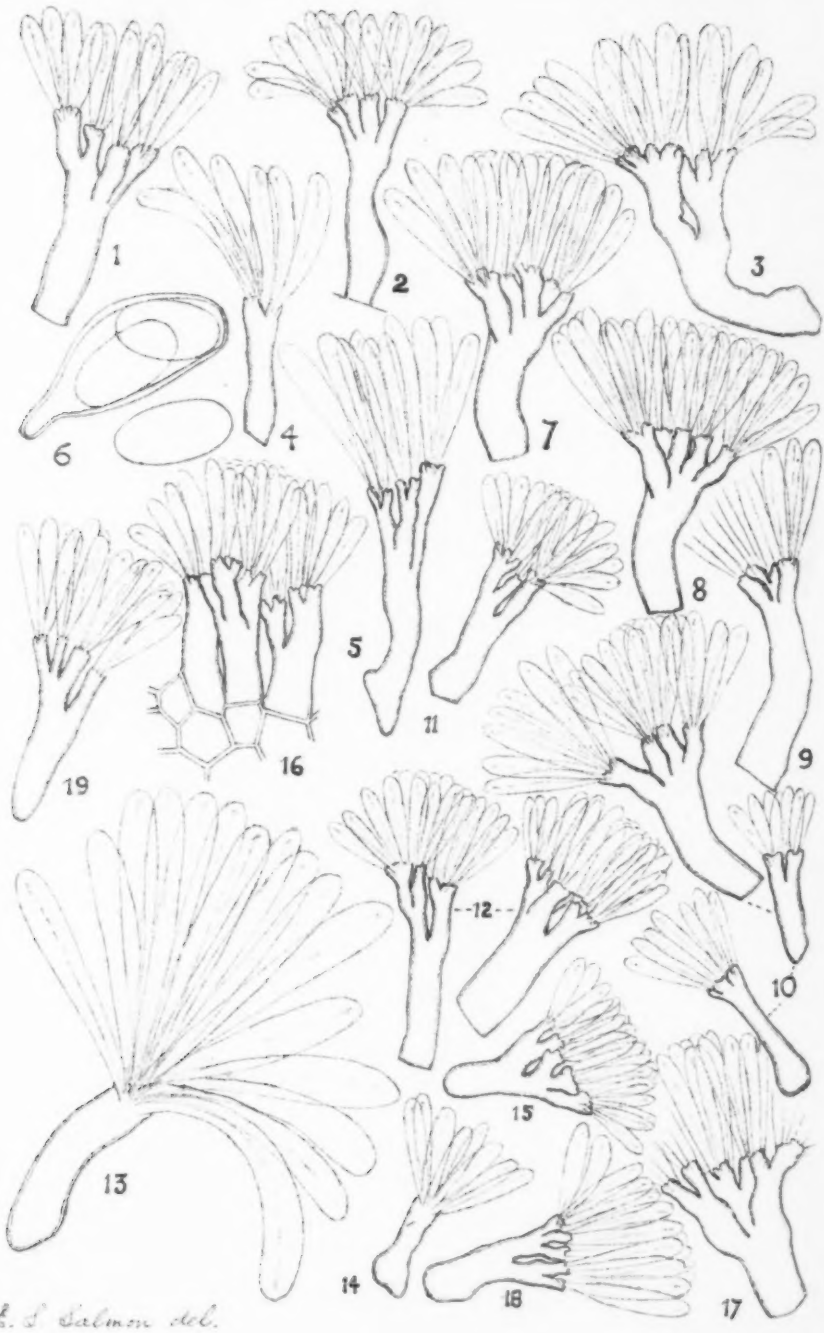

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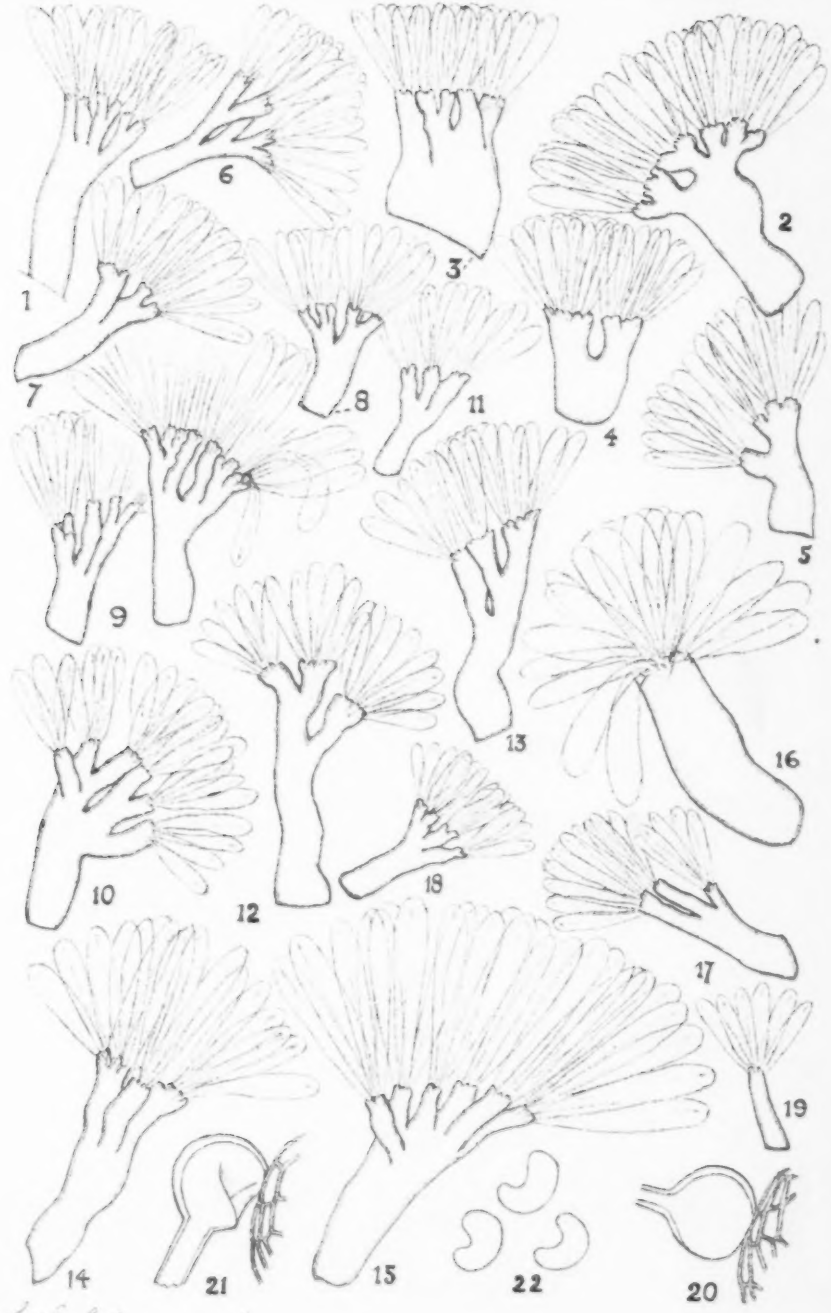

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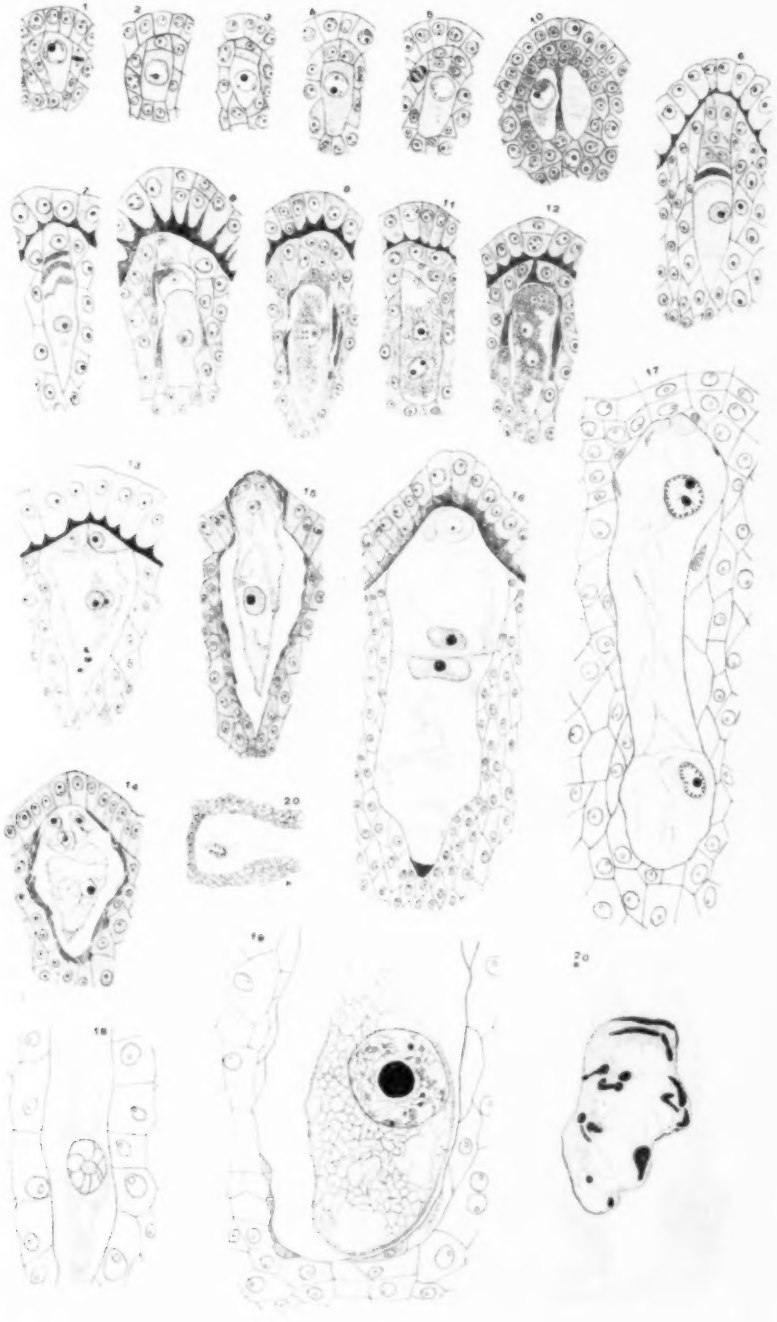

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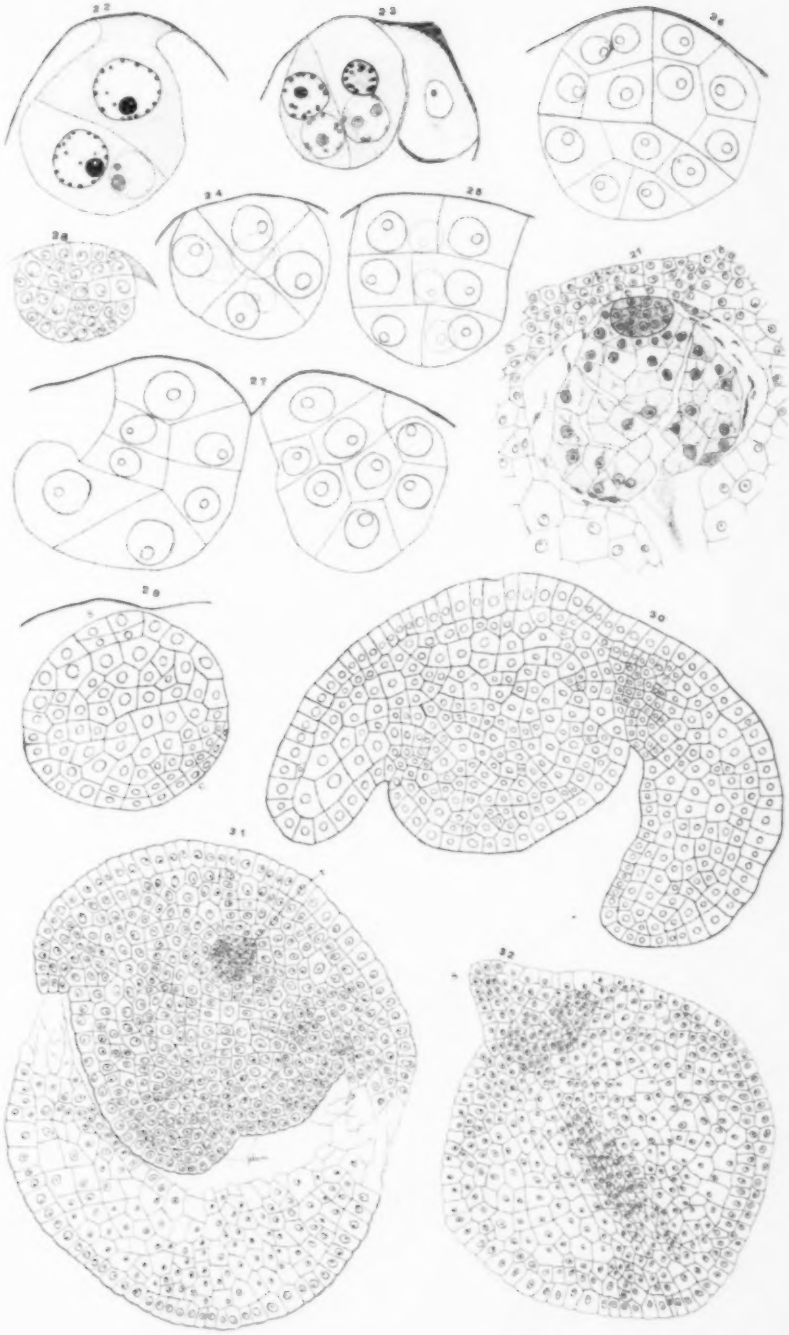

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